GUIDELINES FOR POULTRY-PROCESSING PLANT LAYOUTS

Marketing Research Report No. 878

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with the
College of Agriculture Experiment Stations
University of Georgia

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Rex E. Childs, M. J. Reed, and John A. Hamann

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Appreciation is expressed to the management of the many poultry-processing plants, the equipment manufacturers, and the inspection personnel of the Technical Services Division, Consumer and Marketing Service, who gave helpful suggestions in carrying out the research.

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Guidelines for Poultry-Processing Plant Layouts

By

Rex E. Childs, M. J. Reed, and John A. Hamann [1]

SUMMARY

A step-by-step approach for designing efficient poultry-processing plant layouts is developed in this report. The plant is divided into its principal activity areas and each area is analyzed as to its relation to the overall operation and its interrelation with other areas, equipment arrangement, and space needs. The operations considered involve handling, processing, and ice-packing (receiving through shipping) broiler-class chickens, which are converted into ready-to-cook form at rates of 4,800 and 9,600 birds per hour. Layout designs for each area are illustrated, with emphasis on simplicity, efficiency, and completeness. The layouts are designed from the viewpoint of a plant management that is planning expansion or diversification without major changes in the plant's structural design, or stopping or slowing production.

A model plant-expansion guide is contained in two area layouts. One layout is designed for a plant processing 4,800 birds per hour, and the other for the same plant expanded to accommodate 9,600 birds per hour. The basic considerations involve: (1) Efficient operation of each component area, from receiving the live bird to shipping the ice-packed product; (2) facility and equipment arrangement that permits a smooth, balanced, direct flow of product and materials through the plant; (3) design, layout arrangement, and property-plat features that allow production capacity to be doubled through building enlargement, without plant shutdown or reduction in operating efficiency; and (4) provision for: (a) meeting regulatory requirements, (b) avoiding hazards to product quality, (c) maximum employee comfort and convenience, and (d) effective plant maintenance.

BACKGROUND

Since 1940, methods of processing poultry on a commercial scale have progressed from relatively slow procedures for preparing New York-dressed broilers to high-speed procedures for producing broilers in "ready-to-cook" form. The earlier poultry-processing plants, operated in small areas of 5,000 to 10,000 square feet with low-volume (800 to 1,000 birds per hour) capacity, have been largely replaced by large-volume (4,800 to 9,600 birds per hour) plants operating in large (20,000 to 50,000 square feet), modern facilities that represent sizable investments in machinery and equipment.

Many of the early processing plants were established in buildings that were not originally designed for preparing ready-to-cook poultry. These became obsolete because they could not be readily modified to accommodate new processing methods, equipment, and production rates. Although some of the older plants are still in operation, most modern processing plants were designed and built for the specific purpose of preparing chickens in ready-to-cook form at high production rates (averaging between 4,800 and 9,600 birds per hour). In many of these plants, however, inadequate planning and lack of foresight have resulted in low operating efficiency and difficulties in adopting new procedures and equipment without major structural changes and disruption of operations.

An increasing emphasis on high quality, a continuous demand for greater plant capacity, and the impact of compulsory inspection[2] have made it increasingly important for processing plants to be designed for maximum production efficiency, ease of expandability, and

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[2] Poultry Products Inspection Act, effective January 1, 1959.

sanitation control. From an operational standpoint, management is becoming increasingly concerned with such problems as efficient work methods and plant layout, quality control, preventive maintenance, and efficient use of utilities.

Modern poultry-processing plants have progressed from slaughterhouse operations to modern food-processing installations. To accomplish this complex step, poultry processors greatly increased their investment in processing facilities, equipment, and labor.

Processors, equipment manufacturers, and researchers (both private and public) have made significant contributions in the reduction of processing costs and hazards to product quality. The benefits to producer, processor, and consumer are reflected in the annual commercial-broiler production figures for the United States, which amounted to about 9 billion pounds in 1968 (*12*)[3] and are continuing to increase.

The research described in this report was undertaken to assist plant operators contemplating constructing new plants, or enlarging existing facilities, in continued improvement in processing efficiency by providing them with basic guidelines for overall facility, equipment, and layout planning. The study concentrated primarily on plants that prepare broilers in ready-to-cook form and package them as ice-packed products. Only a limited part of the study was devoted to facilities required for further-processing operations, such as cutting-up chickens, preparing specialty items, and freezing; however, the planning principles presented may also be applied to layouts involving further-processing operations.

Information in this report is based on studies of poultry-processing plants in the Southeast, which were operating at various production levels. Information from these studies was supplemented by information from textbooks, the USDA Consumer and Marketing Service, Technical Services Division, and results of earlier research (*2*, *3*, *4*, *5*, *13*, and *14*).

Work areas and facilities of typical plants were studied and analyzed. In instances where a component area (or a part of a component) proved to be unusually effective, it was carefully studied during processing operations. The layout, arranged on a laboratory layout board, was then tested and rearranged as necessary to facilitate its adaptability to a wide range of operating conditions and overall workability. This procedure was continued until basically sound criteria for facility layout were developed.

PLANNING THE LAYOUT

Processing Operations and Layout Development

The major operations in converting the live birds into ready-to-cook products involve moving the birds by overhead monorail conveyor from the receiving dock through successive processing steps. These steps include loading the picking line, slaughtering, scalding, defeathering, and washing. The dressed carcasses are then transferred to another monorail conveyor that routes them through the eviscerating area for processing into ready-to-cook condition. Finally, the products are chilled and packed. Various other types of auxiliary conveyors are used for live-poultry coops, chilling, weighing, packing materials, packing, further processing, and shipping operations (fig. 1).

Developing a good plant layout by accident is not possible. Each piece of equipment must be purchased and positioned with good reason and purpose, and each processing area must be located relative to other areas to provide the most convenient, direct, and uninterrupted movement of material and personnel. The main objectives of a good plant layout are to provide: (1) A smooth, direct product flow through the plant, (2) economical movement of all materials over distances that are as short as possible, with minimum crossflow and traffic congestion, (3) adequate space for personnel movement, equipment operation, servicing, and proper plant maintenance, (4) an atmosphere that encourages orderliness and goodwill between workers and management, and (5) a design providing for future plant expansion at minimum expense and disruption of operations.

Systematic Layout Planning

Four major steps in planning a plant layout are: (1) Gathering all the facts (total volume to be handled, production rate, styles of product, and so forth) needed for intelligently planning the facilities required for the

[3] Italic numbers in parentheses refer to Literature Cited.

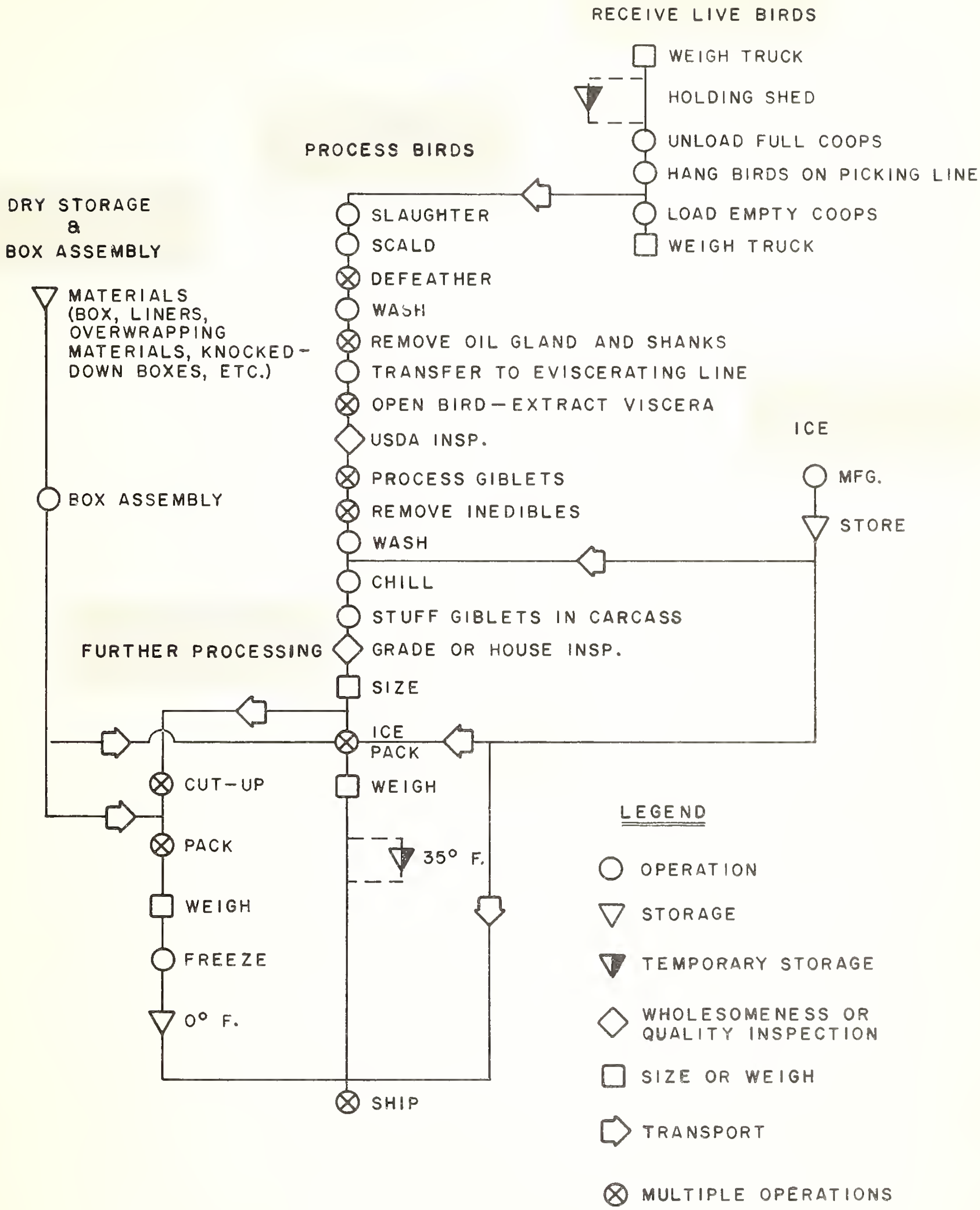

FIGURE 1.—Process chart showing sequence of operations in a typical poultry-processing plant.

present and future operations; (2) determining the processes involved and sequence of operations; (3) establishing the relative locations of departments, activities areas, and work stations; and (4) establishing detailed flow of products and layout of machinery and equipment in each area.

Many factors must be considered when the overall processing-plant layout is prepared. The first important problem to consider is the product form and package type in which the product will leave the plant. The second factor to be considered is the rate of production, both for the present and future. The facts pertaining to these considerations must be known as accurately as possible because they establish, to a large extent, the amount and type of equipment needed and the size and relative location of many plant facilities. Other facts that must be determined include: The type and make of equipment to be used, capacity and size of each piece of equipment, number of employees required for peak production, amount of supplies and materials (such as cartons and ice) to be received and stored, and utility requirements.

Other sections of this report discuss layouts of specific plant areas. For the purpose of illustration, the steps of overall plant layout will be pointed out by assuming that a specific layout is to be prepared for a processing plant with an hourly production rate of approximately 4,800 broilers per hour. Most of the dressed products will be whole ready-to-cook birds shipped in ice-packed form, with 10 to 15 percent cutup, deboned, and so forth.

To provide for orderly planning, the research designers first specify the major activities and the plant areas in which these activities are conducted. The activities and areas are arranged in the order of their occurrence (operations) or of their use (facilities), as shown in figure 2.

The next step is to establish the relation of the different activities and areas (fig. 3) and to position work locations according to predominant traffic-flow direction between areas and activities. The diagram in figure 3 shows the relative location of the areas and has no bearing on the size of specific areas.

The approximate size of each area is then established and a space-relationship-flow diagram is presented to indicated interarea activity and estimated square footage of floor space needed for each activity (fig. 4).

The space requirements for each area of the space-relationship-flow diagram are estimated from actual plant situations and the designers attempt to fit these areas together to permit the smooth flow of product

FIGURE 2.—Major activities or facilities required in a poultry-processing plant.

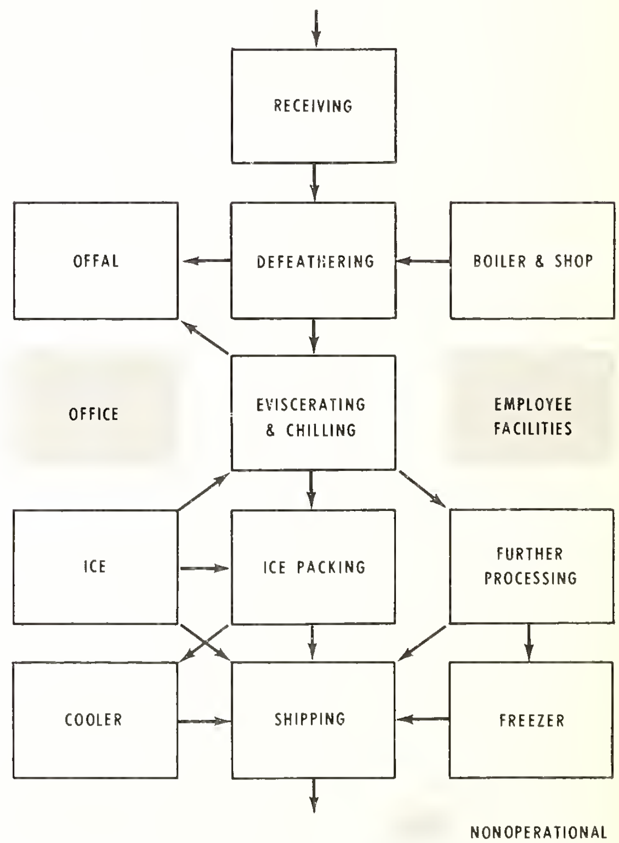

FIGURE 3.—Activity-relationship-plan diagram for poultry-processing plant, indicating flow of product or services between departments.

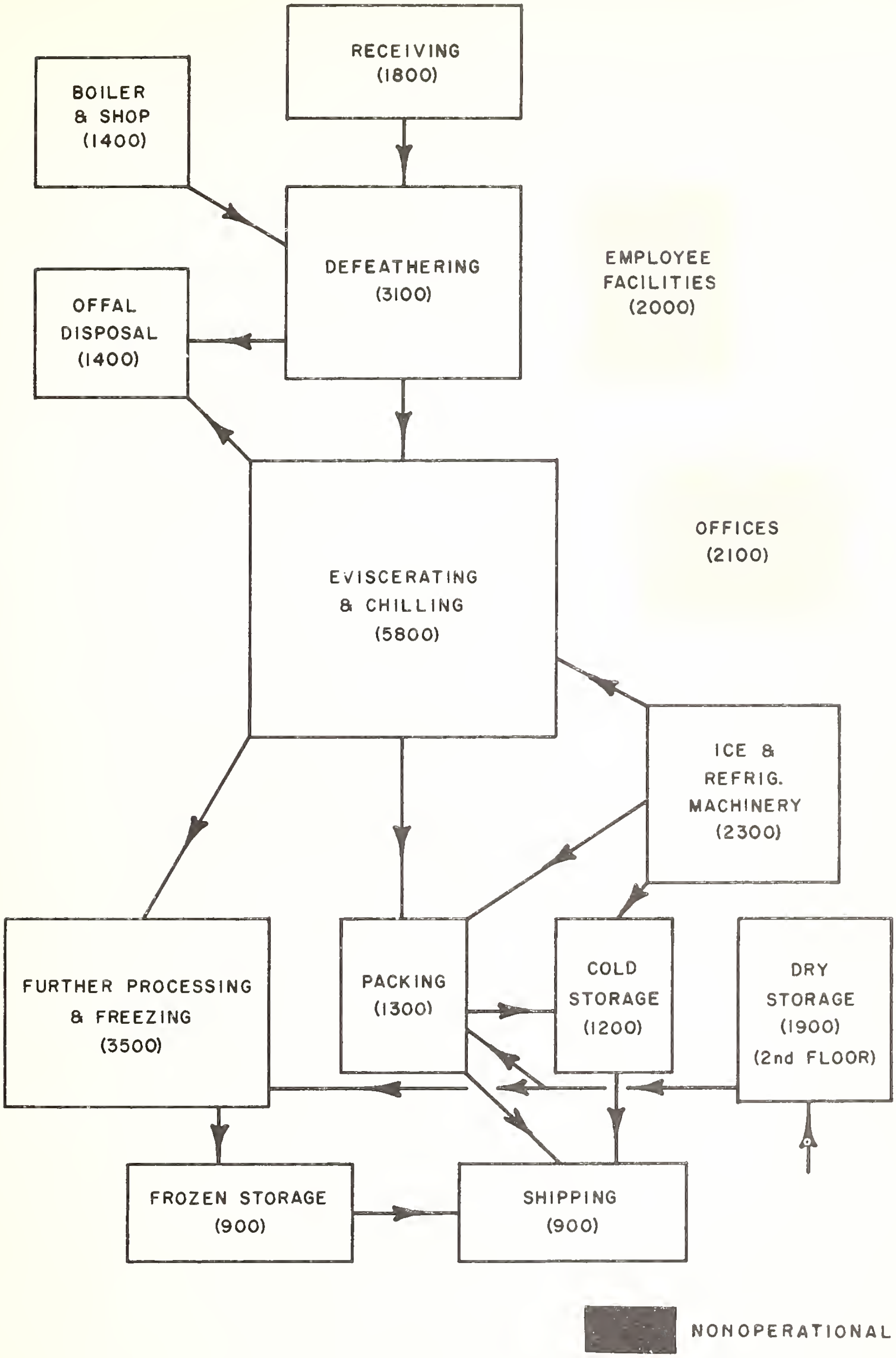

FIGURE 4.–Space-relationship-flow diagram for poultry-processing plant, indicating activity and estimated square feet of floor space needed.

from one area to another. The designers found that a useful method of establishing the relative locations of different areas was to prepare templates of the proper size for each area and to use these templates on scale-lined layout boards for experimentation with different possible locations offering minimum crossflow or traffic congestion.

After the approximate locations of the different areas have been established, flow of products through and between each area is plotted and locations are assigned to the machinery, equipment, and supporting facilities necessary for carrying out the overall processing operation. Although layouts can be prepared by making drawings only, the use of a layout board and templates or models of machinery and equipment facilitates planning by offering the designers a chance to make major or minor changes that would otherwise require time-consuming or expensive revisions of the drawings, or modifications of the actual structure.

LAYOUT EXAMPLE

An efficient layout of the major areas of a medium-size plant (about 4,800 birds per hour) was prepared on a layout board (fig. 5). This layout illustrates area size and location relationship. Equipment placement will be illustrated as individual areas are discussed.

Although many other arrangements are possible, the layout in figure 5 has the main plant areas arranged so as to permit an orderly expansion and to provide the shortest distance between areas whose operations are in sequence with one another.

Figure 6, Plan B, illustrates how plant expansion is achieved in an orderly manner at minimum cost. The dotted lines indicate where original walls were located in Plan A.

Although the increase in overall building space is approximately one-third the original area in Plan A, the plant production capacity has been doubled (9,600 birds per hour). An important aspect of the expansion design in Plan B is that no major changes in auxiliary facility or equipment items were required and that expansion was possible without a shutdown of operations.

RECEIVING DOCK AND DEFEATHERING AREA

Receiving Dock

The layout of the receiving dock and defeathering area of Plan A is shown in figure 7. The live-bird unloading area consists of a sheltered space for positioning two live-poultry trucks at the same time to permit uninterrupted unloading. A platform between truck positions permits side unloading from and loading onto a bilevel coop conveyor. The lower level of the conveyor is used for full coops and the upper level is used for empties (fig. 8). The hanging area provides space for the required number of workers within a fenced enclosure that confines occasional birds that escape during the hanging operation. The receiving office commands a view of the receiving dock and hanging area. A toilet is provided on the receiving dock for the convenience of truck, receiving, and other live-handling crews, and so that dust and dirt from the workers' feet is not carried to the "ready-to-cook" area by personnel going to the main restroom.

Truck-Unloading Facilities

Structural features recommended for the truck-unloading area are: (1) Bays at least 10 feet wide, hard-surfaced, and sloped to gutter drains (concrete is recommended for easy cleanup); (2) roof cover with a minimum overhead clearance of 14 feet extending the full length and width of truck beds and conveyor platforms; (3) platforms at truck-bed height (approximately 46 inches) and 6 to 8 feet wide to accommodate coop conveyors and unloading personnel; and (4) bumper guards of heavy steel-capped timber at truck-impact height.

The most satisfactory slope for coop conveyors was found to be one-fourth inch per foot for wheel-type conveyors and one-half inch per foot for roller conveyors. Slopes that are steeper cause excessive coop speeds, which can result in bird bruising and coop damage. Conveyors for returning empty coops to the truck can

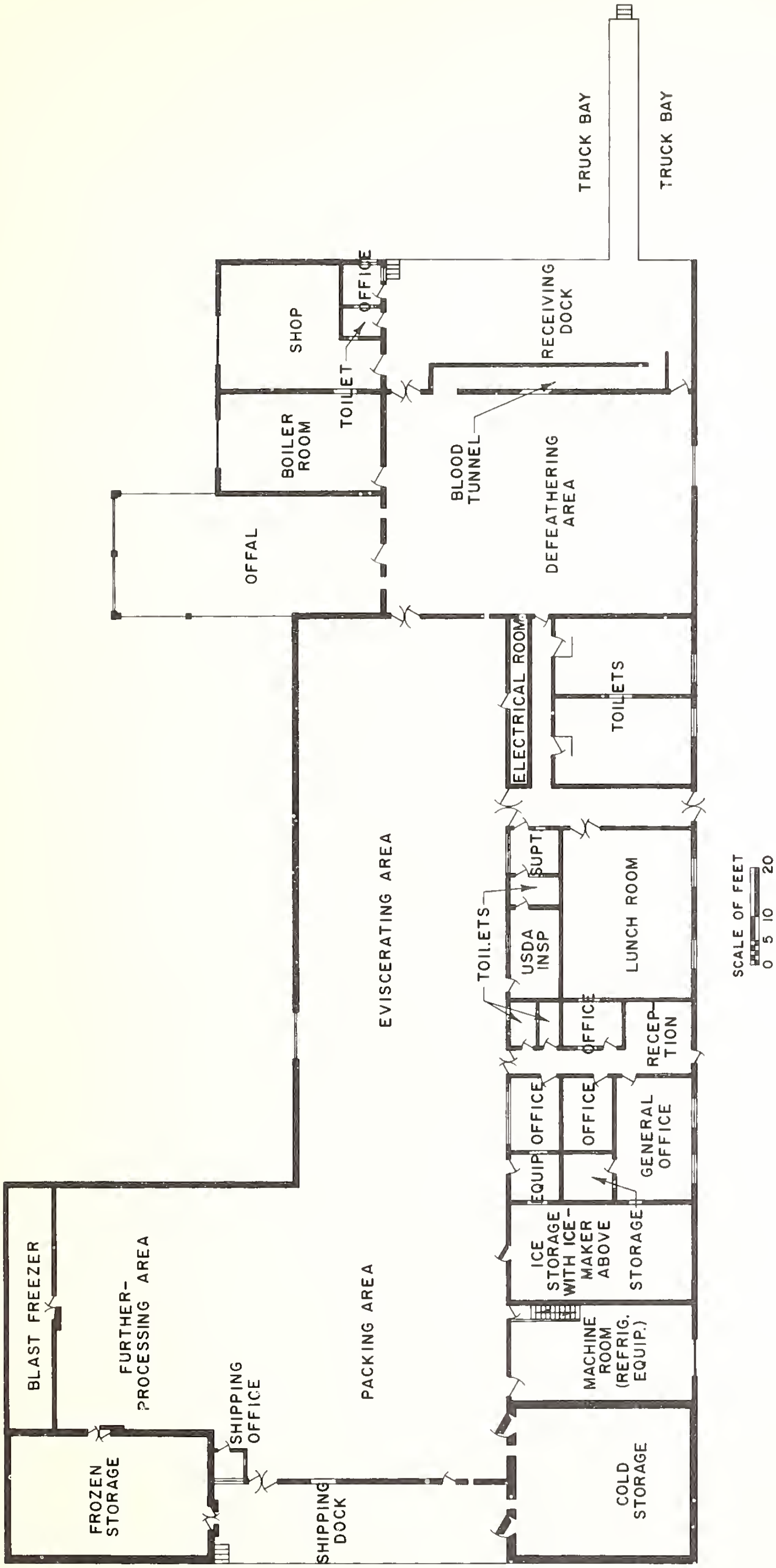

FIGURE 5.—Layout of major areas of model poultry-processing plant (Plan A) designed to accommodate 4,800 birds per hour.

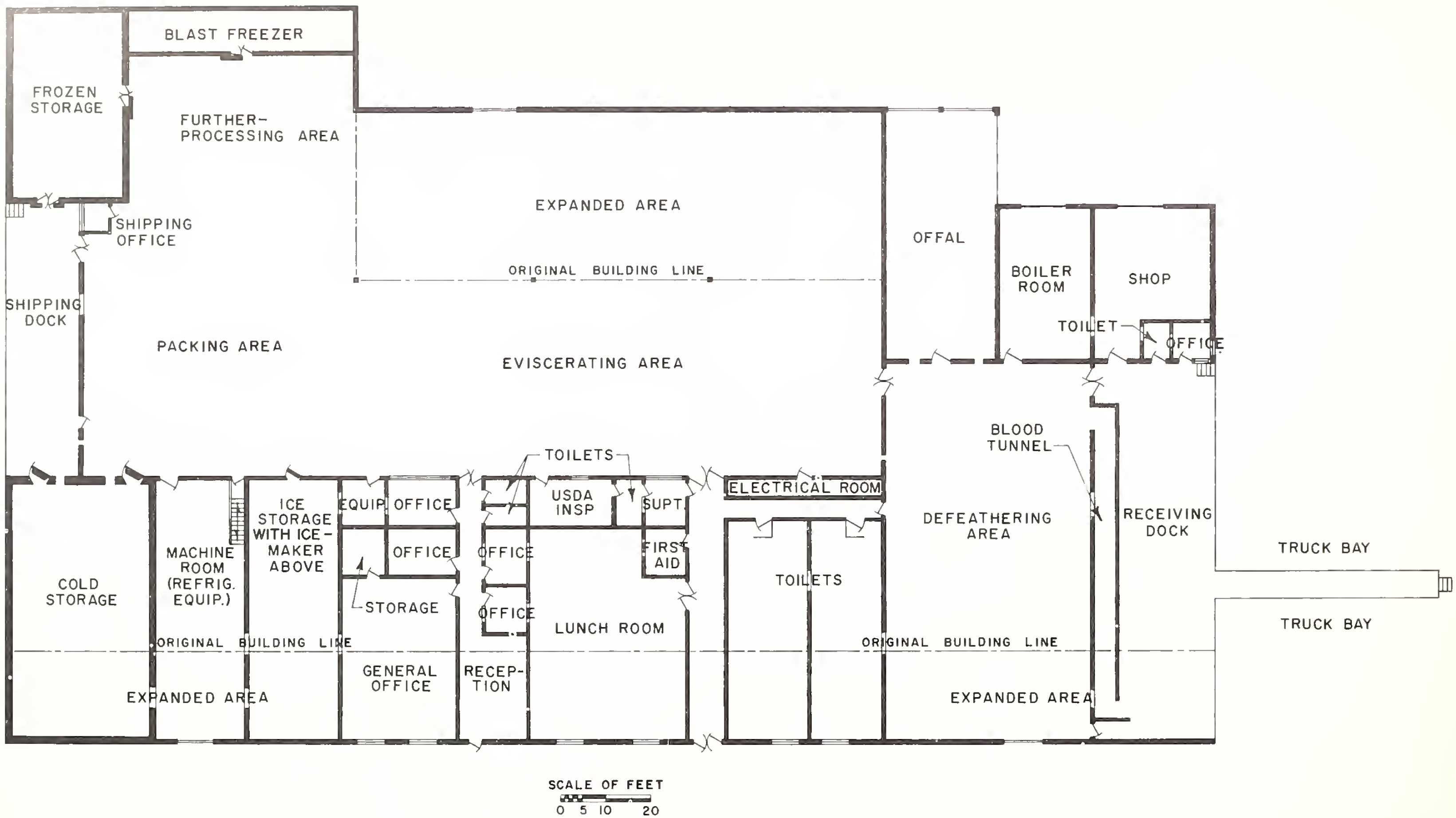

FIGURE 6.—Layout of major areas of model poultry-processing plant (Plan B) designed to accommodate 9,600 birds per hour. This plant layout is an expanded version of the model plant illustrated in figure 5 (Plan A), which is designed to accommodate 4,800 birds per hour.

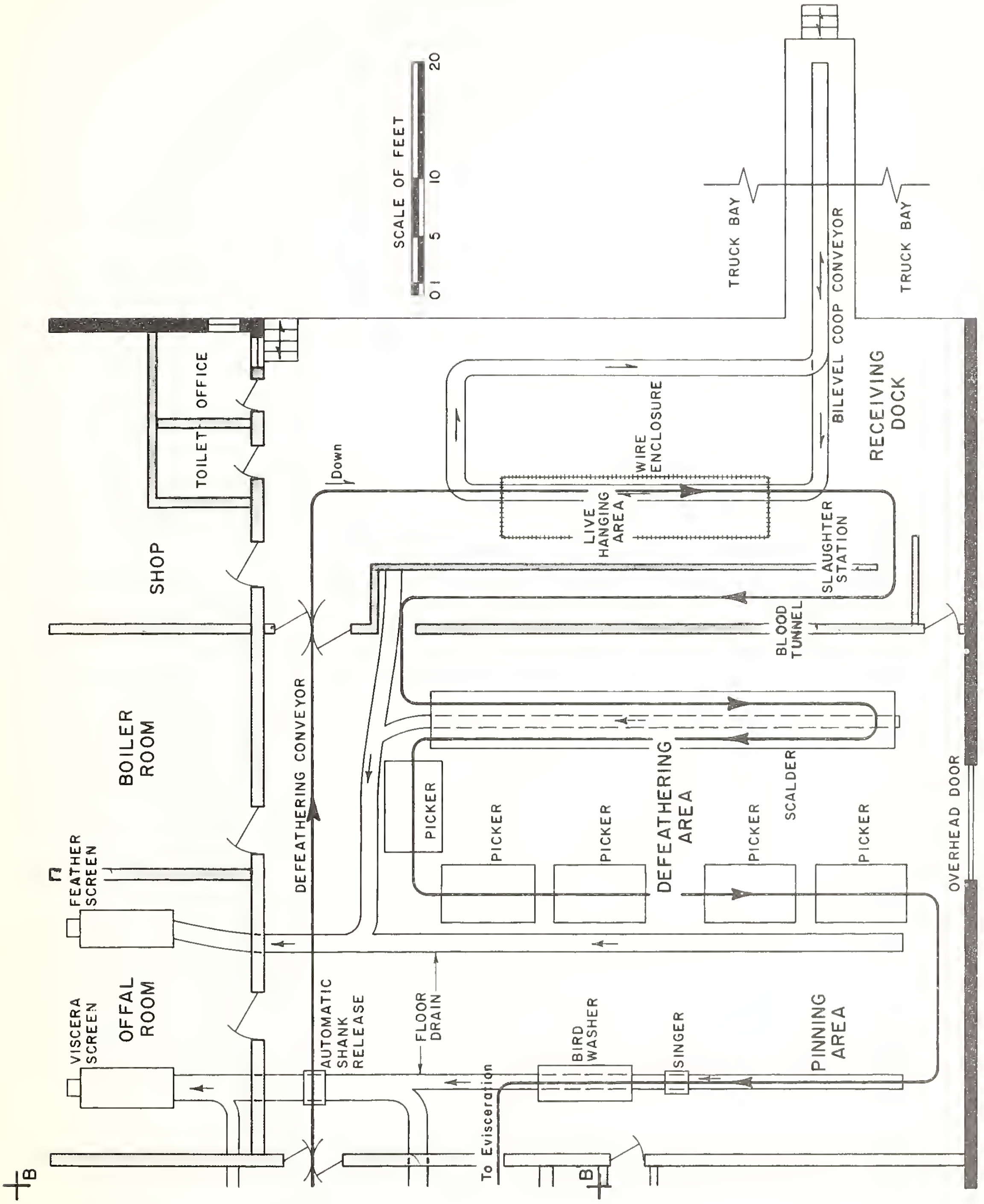

FIGURE 7.—Layout of receiving dock and defeathering area for model poultry-processing plant. A complete layout of the plant (Plan A) is shown in figure 5.

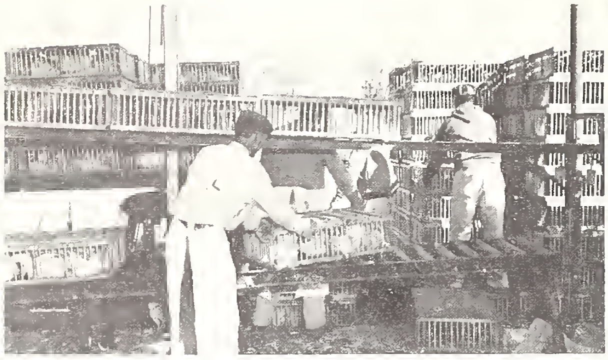

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FIGURE 8.—A bilevel roller conveyor used to receive live birds in a poultry-processing plant. Full coops are unloaded onto the lower level of the conveyor and empty coops are returned on the upper level for loading onto trucks.

be of lighter construction than those that transport the loaded coops.

Hanging Area

Several powered conveyor sections are generally used for movement of coops to and from the hanging area. The power unit that delivers coops to the hanging stations is controlled by the worker at the last hanging position, since it is his responsibility to remove all remaining birds from each coop. The bottoms of the hanging shackles clear the coop tops by about 18 inches to prevent contact between the coop tops and the shackled birds. The tops of the coops are approximately 3 feet above the floor level, a distance providing workers with ready access into the coop and a short reach to the shackles. A fence around the hanging position (fig. 9) is used to confine birds that escape from coops during the emptying operation.

The conveyor at the hanging stations should be straight and of sufficient length to hold at least the same number of coops as there are workers to hang birds. Since the standard coop is 35 inches long and an average worker can hang about 950 birds per hour, the length required for the straight conveyor section can be readily determined for plants of various processing capacities. It is recommended that space for two extra coops be provided for standby capacity.

The receiving dock requires: Floor space for work crews and unloading and loading equipment; space heaters; hot and cold water outlets or a steam-mixing valve for cleanup; water fountain; overhead lighting fixtures; and power outlets for fans, conveyor drives, and portable power tools. The amount of lighting required will depend upon natural light available and contemplated hours of operation. For a plant scheduled to operate during the daytime only, 10 foot-candles of artificial supplemental lighting is sufficient. When night operations are to be conducted, lighting of at least 20 foot-candles will be needed. If drains from the receiving area are to be connected to city sanitary or storm drains, local authorities may require some type of screening or trapping. Several fans, mounted near the outboard side of the receiving dock and exhausting toward the trucks, will help reduce dust in the hanging area and will provide ventilation for poultry on the trucks during hot weather.

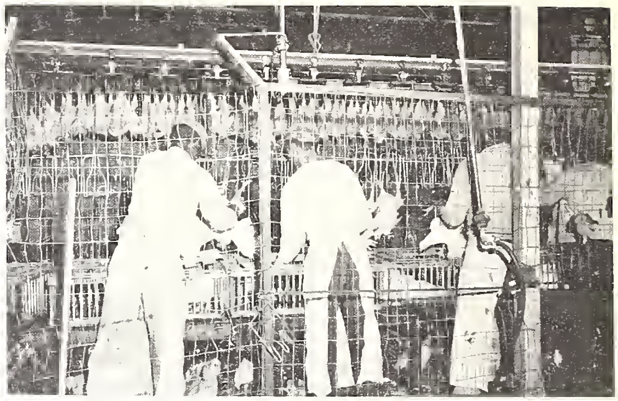

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FIGURE 9.—Broilers received in poultry-processing plant are removed from coops and shackled to overhead monorail conveyor for slaughtering and defeathering. Coops rest on a powered belt conveyor activated by a knee-operated switch (not visible).

Various types of walls or enclosures can be used on the receiving dock. Solid walls completely enclosing the hanging area (with openings provided for doors, conveyors, and fans) are used in some instances, whereas a combination of solid walls and fenced or screened partitions are used in others. In most plants the side facing the truck apron is left completely open. In winter, the fenced or screened partitions are generally covered with sheet plastic or other translucent material.

Slaughter Area

After the chickens are shackled in an inverted position to the overhead monorail conveyor (fig. 10), they must remain suspended for about 1 minute while the conveyor transports them to the slaughter area. This period of inverted suspension is required to quiet the birds before they are slaughtered.

Sanitary regulations require that blood from the slaughter operation be confined to a relatively small area. This requirement is satisfied by providing for a blood tunnel in the layout design. The blood tunnel is a long narrow hall about 5 feet wide and of sufficient length to allow up to 1-1/2 minutes of bleeding time (actual length is determined by line speed and time) for

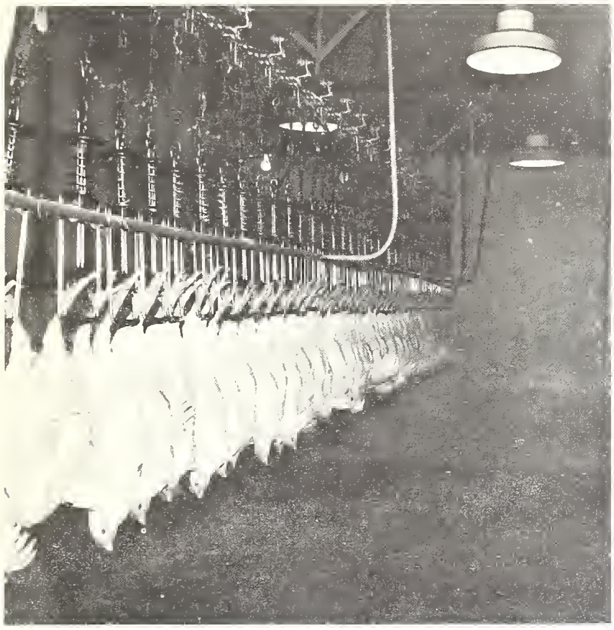

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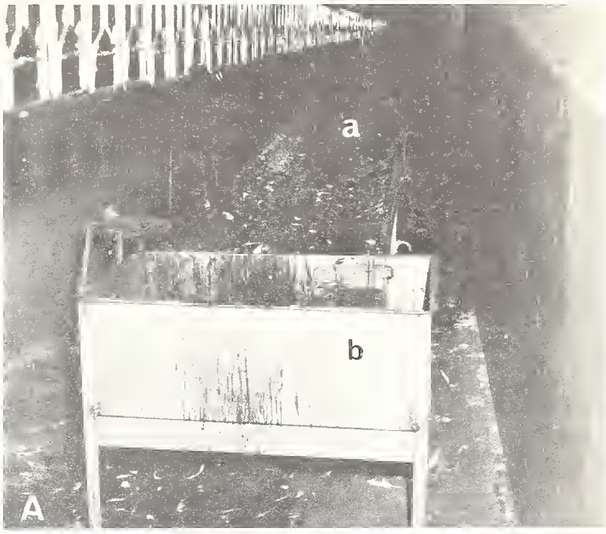
FIGURE 10.–Suspended position quiets birds attached to overhead conveyor for transport to slaughter station in poultry-processing plant.



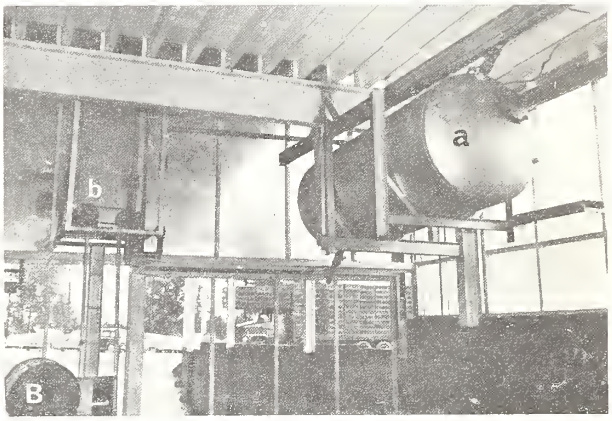


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FIGURE 11.–Blood-disposal system in poultry-processing plant. *A*, Equipment in slaughter area used to accumulate blood: *a*, Inclined metal trough catches blood at slaughter; and *b*, catch basin at end of trough accumulates blood at cleanup. *B*, Overhead equipment in offal room used to collect and remove accumulated blood: *a*, Collector tank receives blood from vacuum line attached to catch basin; and *b*, vacuum pump serves blood disposal system and, with motor reversed, creates pressure in collector tank for emptying blood directly into offal truck.

the birds before they enter the scald tank. Bird slaughter is carried out at the entrance to the blood tunnel. If a shorter bleeding time is needed for some groups of birds, the slaughter station is moved farther down the tunnel.

Since city sanitation laws usually prohibit the release of blood into sewer lines, most poultry plants dispose of blood by mixing it with offal or feathers, which are then sold to feed-supplement processors. The blood must be transported from the tunnel to the offal truck, either by scooping it into barrels after it has congealed, moving it to the offal room by handtruck and flushing it through a floor gutter to the feather-receiving station, or by moving it through a vacuum system to a collector tank in the offal room, a system similar to that used for lung removal.

The system illustrated in figure 11 shows a metal trough and catch basin installed in the blood tunnel to accumulate the blood for drawoff at cleanup time. At cleanup, a vertical sliding panel is removed and accumulations in the trough are allowed to slip into the catch basin; congealed blood is broken up by being passed through a coarse screen. A 2-inch plastic vacuum hose is attached to the bottom of the catch basin and the blood is drawn off by vacuum to the collector tank. During shutdown periods the tank can be emptied by pressure and gravity flow directly into the offal truck.

Regardless of the handling system used, floors and floor drains should be designed for efficient removal of blood and cleanup waste water. Standard practice provides for smooth floors sloped approximately one-fourth inch per foot to floor drains that are no more than 20 feet apart. Blood-tunnel walls should be impervious to moisture and easily cleaned.

Utility outlets and fixtures required for the slaughtering station and blood tunnel include a unit heater near the slaughter station, fixtures that provide lighting of 30 foot-candles at slaughter station and 10 foot-candles elsewhere, an exhaust fan, and hot- and cold-water outlets or steam-mixing valve with hose.

Defeathering Area

Processes carried on in the defeathering area include scalding, feather removal, singeing, manually removing any remaining pin feathers, and mechanically washing each bird. Other operations that are sometimes performed in this area are oil-gland and shank removal.

The requirements for the defeathering conveyor layout (length, height, horizontal and vertical turns, supports, and drive-unit capacity) can be planned only after the floor space, ceiling heights, and equipment layout of the defeathering area have been determined. In planning the defeathering area and equipment arrangement, careful consideration must be given to selecting a layout with a conveyor of minimum length and complexity.

The defeathering conveyor, like other pieces of equipment, is generally selected on the basis of equipment and operating costs. However, there are other factors that should be considered from a long-range view. For instance, reliability is absolutely essential. (A brief shutdown in the defeathering area means a corresponding shutdown in the eviscerating room.) Durability, economical upkeep, adequate power, and standard motors that are easily replaced are necessary for satisfactory service. Provision for variable-speed drives in motors permits operating flexibility. All of these attributes should provide the dependability that is required for the critical defeathering operation.

Minor considerations of importance to a smooth operation include shackles installed at uniform height below the conveyor trolley to insure best picking performance and reduced wear on rubber-picking fingers, and hanging pendants interconnected by small rod or chains to prevent tangling of adjacent shackles during movement through scalders and pickers.

Equipment Arrangement

The scald tank, overhead conveyor, and picking machinery are laid out to provide adequate space for personnel movement, maintenance, and shifting of equipment items without the necessity of moving other equipment (fig. 7). The floor gutter drain used to receive feathers is located at one side of the row of picking machines so that birds accidentally released from their shackles may be recovered before they reach the gutter. Floor gutters are also provided for floor drainage and for receiving the water from the bird washer and scalder. The floor space between the last picker and the singer provides space for three or four workers engaged in removing pin feathers. An overhead door is provided to allow movement of large equipment into and out of the defeathering area as the need may arise.

Scalding

Most scalders are manufactured in sections that can be fitted together to obtain the desired length, and are provided with devices for temperature control and water agitation. The length of the scald tank must be sufficient to allow birds to be immersed from 1-1/2 to 2 minutes (length is determined by line speed and conveyor design). Better space utilization has been achieved with scald tanks constructed so that the conveyor can make two or more passes through them. The "two-pass" tank is most commonly used when the birds are moved along one side on entry and along the other side on the way out, so that they enter and leave through the same end (fig. 12).

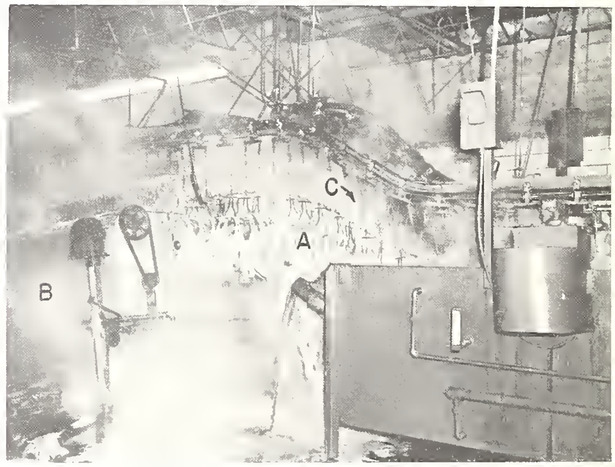

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FIGURE 12.–During commercial processing, birds leave the scalder (*A*) and enter the first picker (*B*). Barely discernible in the background are the birds entering the scalder (*C*). The typical steamy condition in the area shows the need for adequate ventilation in the defeathering area.

Scalders with three or four pass tanks can also be obtained for special cases where linear space for long scalding units is not available.

Adequate clearance should be provided between the scalder, other equipment, and walls for performance of maintenance work, cleanup, and movement of equipment. Walls and ceiling should be constructed of materials that are impervious to moisture. The floor should be provided with drains to handle the scalder overflow (estimated at 1 quart per bird) and water from the tank drain and cleanout fittings. Good ventilation is essential to prevent heat and moisture buildup in the area. Exhaust fans capable of affecting one air change of

the area per minute are considered satisfactory. Fresh air inlets, screened and of adequate size, must be provided for entrance of clean air into the area. Other features required for the scalding area are a number of well-located steam, water, and power connections, and 20 to 30 foot-candles of lighting.

Feather Removal

For the best results, picking should begin immediately after the birds emerge from the scalder (fig. 12); therefore, the first picking machine should be placed as close to the exit end of the scalder as possible. The number of picking machines used is determined by the type of machines, condition of the poultry, and production rate. Observations in several plants indicated that as few as three picking machines were used for a production rate of 3,000 birds per hour and that as many as seven machines were used for a production rate of 9,600 birds per hour on single-conveyor picking lines.

Neck and hock scalders ranging from 4 to 10 feet long are used on the picking lines of many plants to facilitate the removal of neck and hock feathers. The location of these scalders depends upon the type of pickers used. Many of the plants studied "reverse-hang" birds (change suspension from leg to neck) at some place in the picking cycle to insure complete picking of all parts of the carcasses. Recent development of multipurpose picking machines has tended to reduce the number of picking machines required and the necessity of reversing the birds.

After specific types of pickers have been selected and their physical dimensions determined, the layout can be planned. Important considerations in the picking-area layout include:

1. Accurate alinement of pickers with the overhead conveyor to give best picking action and to prevent breakage of picker fingers.
2. Provision for adequate space between adjacent pickers (at least 30 inches) and between pickers and walls for movement, adjustment, maintenance, and cleanup. An ideal layout would provide sufficient space and clearance to allow any piece of equipment to be removed and replaced without movement of other equipment.
3. Provision of feather "flowaway" gutters to receive and dispose of feathers from each picker (fig. 13).
4. Power outlets and switch controls for picking machine motors.

Because of hot, humid conditions in picking rooms, electrical distribution panels should be separated in a low-moisture atmosphere room, but located as close to the picking room as possible. However, motor switches should be located convenient to the picking-room supervisor, so that the supervisor can stop any motor quickly in an emergency. Location of the switches in one panel, such as that shown in figure 14 *A*, allows any or all switches to be operated from one location. All electrical controls and wiring should be waterproof.

Safety switches should be installed at or near equipment where a hazard to operator safety exists. For example, an employee might be dragged into a picking machine if his hand became entangled in a poultry-conveyor shackle. Figure 14 *B* shows a safeguard against this hazard in the form of a safety switch located at the front entrance of a picking machine; the switch controls the conveyor and picking-machine motors.

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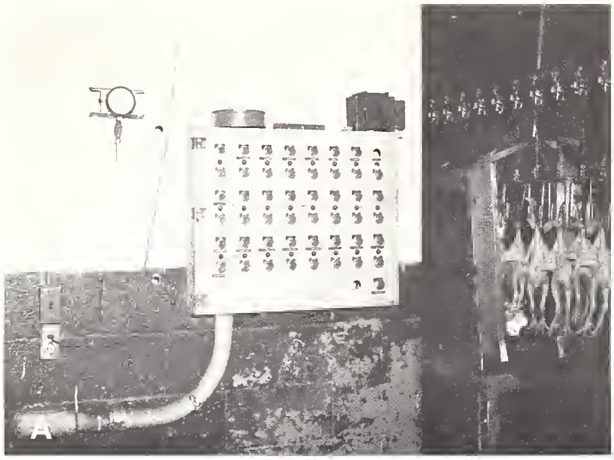
FIGURE 13.—A floor gutter drain for floating feathers from the defeathering area to the offal room. Water-flushed feather tray (arrow) of first machine is shown discharging into floor gutter.

Pinning

The number of pinners[4] required and the space and length needed for the conveyor in the pinning area

[4]Workers assigned to remove occasional pinfeathers remaining on poultry carcasses after mechanical defeathering.



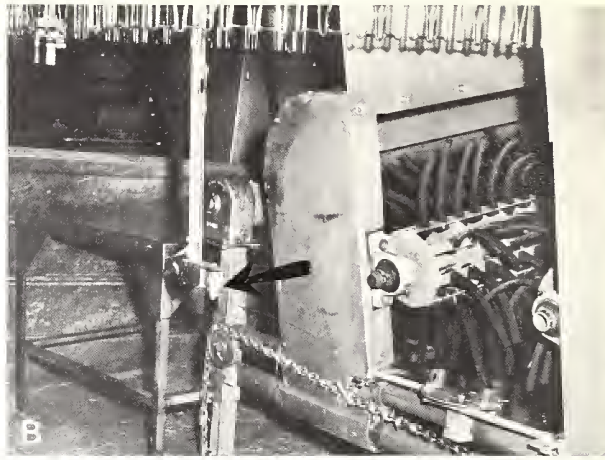


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FIGURE 14.–Hazards to safety in defeathering room of poultry-processing plant are reduced by switches that control motors of conveyors and mechanical picking machines. *A*, All motor switches are located in one electrical panel fitted with on-off push buttons and indicator lights. *B*, Safety switch (arrow) is located at front entrance to picking machine.

depend more on picking-equipment effectiveness and bird condition than on the processing rate and conveyor speed. Faster picking lines with up-to-date, properly maintained equipment that process birds in proper condition often do a better job of picking than slower picking lines with older or poorly maintained equipment. Consequently, less effort and space is required for a well-conducted pinning operation.

Bottoms of shackles should be approximately 54 inches from the floor as they pass through the pinning area so that the birds are carried past the workers at a convenient height for examination and removal of occasional feathers. The pinning operation requires a close inspection and, consequently, good-quality lighting of 30 to 50 foot-candles is needed at the work stations.

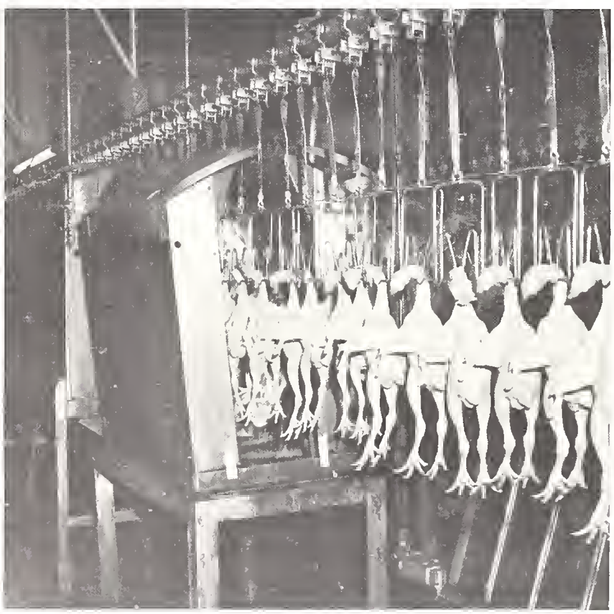

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FIGURE 15.–Birds enter an enclosed singeing device during commercial processing.

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FIGURE 16.–Commercially processed broilers are conveyed through an "outside" bird washer (in the background) after they have been inspected for pinfeathers and singed.

Singeing

Singeing (fig. 15) is accomplished at the end of the pinning line by momentarily enveloping each carcass in a gas flame. To do an effective job, the singer should be located far enough from the last picker to permit as much drying of the vestigal feathers[5] as possible. The height of the singer should assure the engulfing of each bird in flame. Although the optimum distance that the singer should be located from the last picker is largely a matter of trial and error, observations in case-study plants and the experience of plant operators indicate that a distance of 25 to 30 feet (including line length for pinning) is adequate.

[5] Hairlike feathers.

Washing

A thorough washing of the carcass is necessary before birds are transferred to the eviscerating line. Washing is carried out by conveying the birds through an enclosed "outside" bird washer (fig. 16) that contains a number of water-spray nozzles.

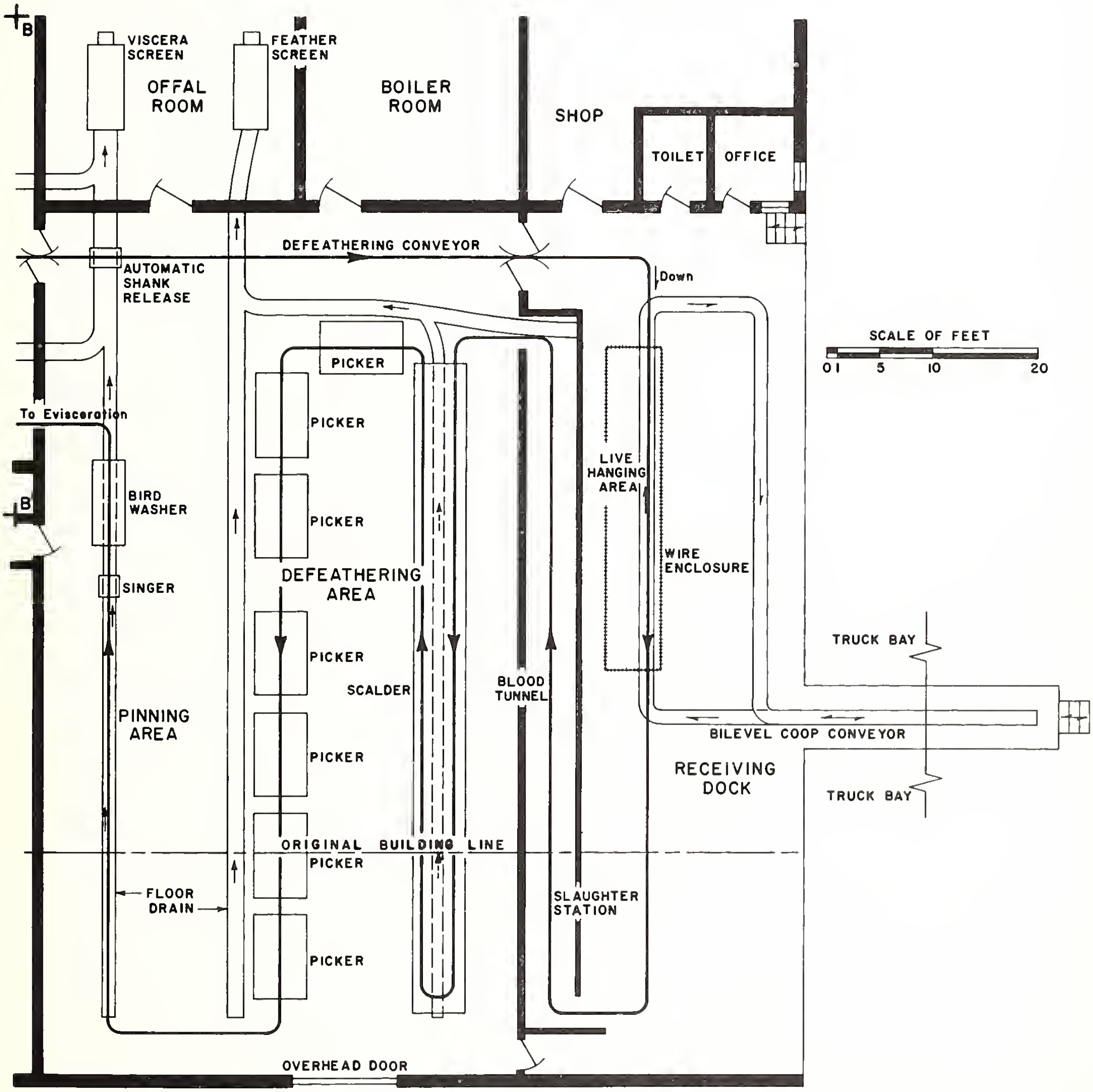

FIGURE 17.—Layout including expansion details for receiving dock and defeathering area of model poultry-processing plant (Plan B, shown in fig. 6). With this expansion, production capacity is doubled to 9,600 birds per hour.

Expansion of Receiving Dock and Defeathering Area

The layout arrangement of the receiving and defeathering areas shown in figure 7 can be expanded to double the production capacity with a minimum of interference to existing facilities. Expansion is achieved by adding facilities to one side only of the area (fig. 17). About 21 feet was added to the width of the building design to accommodate additional pickers and necessary extensions of coop conveyor, hanging area, blood tunnel, scalder, and defeathering conveyor.

EVISCERATING AND CHILLING AREA

In plants preparing whole ready-to-cook chickens packed in ice, approximately 50 percent of the plant workers are employed in the eviscerating area. Design of this area layout, therefore, requires special attention to work-station and aisle space, and to proper placement of personal facilities for employees.

Eviscerating Area

The main equipment item in this area is the eviscerating conveyor line with water-flushed trough underneath (fig. 18). One of three monorail conveyor arrangements is normally used to route either a single or a double line of birds over the water-flushed trough *(4)*. The conveyor height along the evisceration line should be gaged so that the conveyor presents the bird at approximately elbow height to the tallest workers. Adjustable platforms should be used to elevate shorter workers to the same height. Conveyor wear can be decreased and maintenance costs reduced if horizontal and vertical curves are held to a minimum.

Three feet of work-station space is generally considered adequate for each worker at the eviscerating trough, with 4 feet each allotted to Federal poultry inspectors and their assistants (fig. 19). Additional space is often included for training new employees and to provide for increased production without moving regular items of equipment that required a fixed location. (Relocation of equipment is expensive because it frequently requires changes in the plumbing and electrical lines.)

The trough normally employed for a single eviscerating line is narrower than that required for two lines over one trough. If use of a dual line is contemplated at a later date, initial installation of a wider trough will make the conversion simpler and less expensive because fewer changes to the plumbing and electrical system will be required, and the cost of a completely new water-flushed trough will be eliminated. A straight eviscerating trough provides a path of least resistance to flow of water and waste products.

The trough drain is located so that the water from the final bird washer can be used to flush waste material from the trough. Most of the waste products, including crops, heads, viscera, and gizzard waste, are dropped into the trough between the gizzard-removal work station and the final bird washer. Therefore, the runoff from the washer is used to carry off this waste to the trough outlet, located at a convenient position between the gizzard-removal station and the end of the eviscerating trough. Locating the outlet near the gizzard station places it near the middle of the trough and makes possible twice as much trough slope to ensure rapid runoff of the water and processing debris—a critical waste-removal problem in poultry-processing plants.[6]

Adequate aisle space in the evisceration area is essential for personnel safety, and for minimizing damage to walls and fixed equipment by maintenance and material-handling equipment. Unobstructed aisles 4 to 6 feet wide on each side of an evisceration line (not including space for workers) are suggested as practical.

The eviscerating area in figure 19 is a long, rectangular space designed to accommodate as many of the eviscerating operations in as straight a line as possible and to minimize congestion. The guard rail between the eviscerating and adjoining areas reduces the crossroom traffic.

Figure 20 illustrates expansion of the layout illustrated in figure 19. With this expansion, the plant eviscerating capacity is doubled.

An L-shaped eviscerating trough is used for the second line (fig. 20) to conserve space (especially in the further-processing area), and to make common use of conveyor belts at the transfer station.

Chilling Area

Several types of in-line mechanical chillers operating on the continuous flow principle have in most instances replaced the tank type method of chilling broilers in large-volume processing plants. When in-line chilling is employed (fig. 21), birds are transferred directly from the eviscerating line to the chiller and are moved slowly through a cooling medium composed of slush-ice or ice-water, or both. Chiller types include either a long,

[6] Research relating to the practice of using water as a waste carrier in poultry-processing plants and to water conservation in industrial operations was begun in 1969.

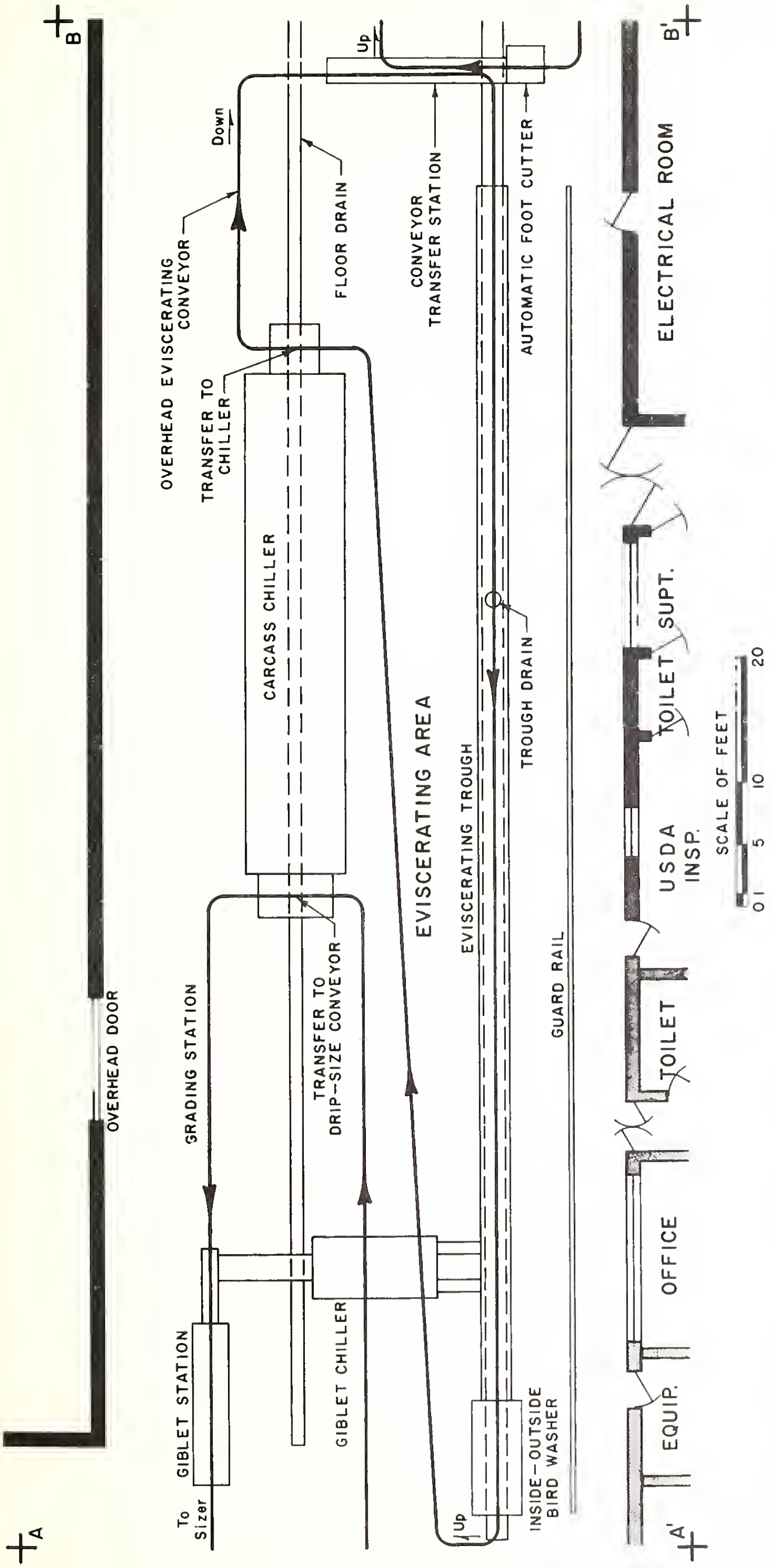

FIGURE 18.--Layout of eviscerating and chilling area for model poultry-processing plant. A complete layout of the plant (Plan A) is shown in figure 5.

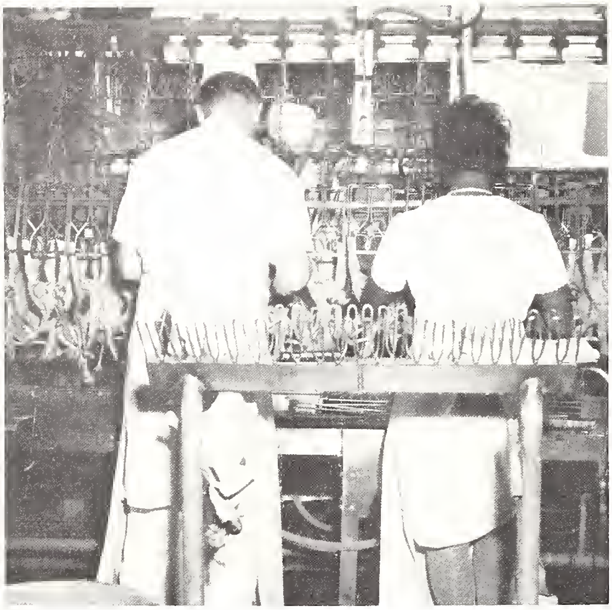

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FIGURE 19.–A Federal poultry inspector (*left*) and his assistant (*right*) normally spaced at their work stations.

deep trough (stationary or employing a rocking motion) or a large rotating drum-shaped tank. The birds are conveyed through the cooling medium by a monorail conveyor, a screw conveyor, water movement, or a combination of equipment and water movement.

An in-line chilling system is a permanent installation that is tied into the eviscerating, sizing, packaging, and further-processing systems by monorail conveyor. Therefore, the permanent position of the chiller as it relates to these operations and to the source of the ice supply is a critical layout factor. In old building structures where expansion is required, the available space can very well dictate the chiller-equipment arrangement. However, in new plants, the arrangement of chiller equipment and the processing layout can be developed for maximum operating efficiency. Even during expansion of existing facilities, it is well to weigh the advantages of alternate arrangements and different types of equipment to obtain maximum efficiency.

In-line chillers vary a great deal in physical characteristics and size. Therefore, the type selected will have considerable influence on the layout of the chill area in relation to other areas and items of equipment. But regardless of the type of equipment selected, provisions have to be made to convey water, chickens, and (for most types) ice into the chillers by the most economical means. Further, chilled birds and waste water must be removed from the chillers. Finally, the chillers require frequent cleaning and routine maintenance.

After these fundamental considerations and the physical dimensions of the chiller selected have been considered, an efficient layout can be planned. The problem of supplying water and electrical power to the chillers has little influence on layout arrangements. Providing a drain system to receive waste water from the chillers is not a serious problem either, but requires planning so that this drainage can be linked to the plant system as conveniently as possible. If ice is required, however, transporting the ice to the chiller becomes a major problem and should be solved by considering alternate plans.

Because of melting and caking, ice is not an easy material to handle even with the best conveying equipment and storage facilities. Therefore, the chiller location in the layout must be planned to minimize problems that are aggravated by distance. Under normal conditions, about 2 pounds of ice is required per chicken chilled. Because of this requirement, from 5 to 10 tons of ice per hour is needed in most plants. This large consumption of ice justifies a considerable outlay of effort and resources aimed at developing a dependable storage and delivery system.

The flexibility of the monorail conveyor used to transport chickens to and from the chiller makes it possible for the chill area to be laid out in practically any space where room is adequate and where the location is convenient to the ice supply. In new facilities, careful planning can result in considerable cost savings, especially if more expensive types of drip-sizing conveyors[7] are considered.

Chilling-Equipment Layout

Specific layout arrangements for chilling equipment cannot be made without understanding the circumstances under which the chillers will be operated, the type of chillers selected, and the types of equipment to be used in the eviscerating and packaging departments. However, some guidelines can be suggested that will help avoid bottlenecks in product flow, keep equipment investment to a minimum, encourage maximum use of

[7] The drip-sizing conveyor combines the monorail conveyor from which chilled carcasses are suspended (to permit complete drainage of chill water prior to weighing) with the bird-sizing conveyor, the shackles of which are part of the weighing mechanism.

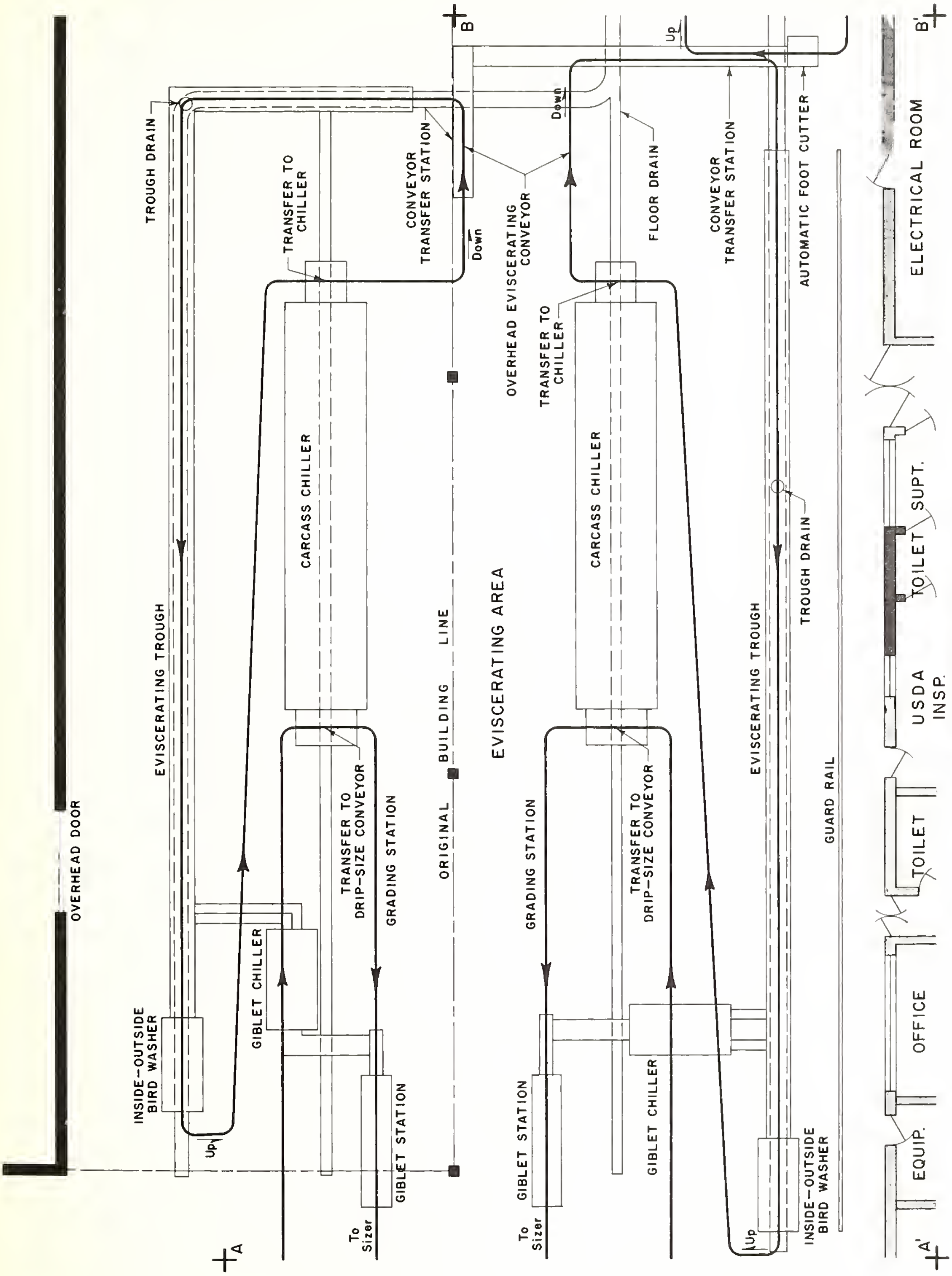

FIGURE 20.—Layout including expansion details for eviscerating and chilling area of model poultry-processing plant (Plan B, shown in figure 6). With this expansion, production capacity is doubled to 9,600 birds per hour.

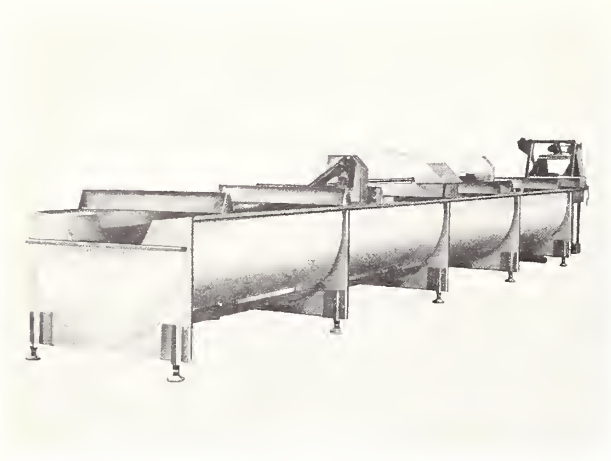

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FIGURE 21.—A paddle-agitated chiller. An oscilating or rocking paddle action moves a continuous flow of poultry carcasses through ice-chilled water during commercial processing.

floor space, and make future expansion less expensive. These guidelines incorporate basically sound layout planning that provides adequate aisle space for workers, product movement, and equipment servicing.

For convenient, economical future expansion, the layout design must provide for expansion to larger capacity equipment and facilities at night, or during weekend downtime, to avoid disrupting production schedules.

Alternate Eviscerating- and Chilling-Area Layouts

Since the layout of eviscerating and chilling areas depends upon such factors as the location of other plant areas, types of equipment used, and expansion plans, one standard design cannot possibly cover all situations. Examples showing two additional layouts of major equipment items are illustrated in figures 22 and 23. A grading and sizing station is also included to show the complete route of the drip-sizing conveyor.

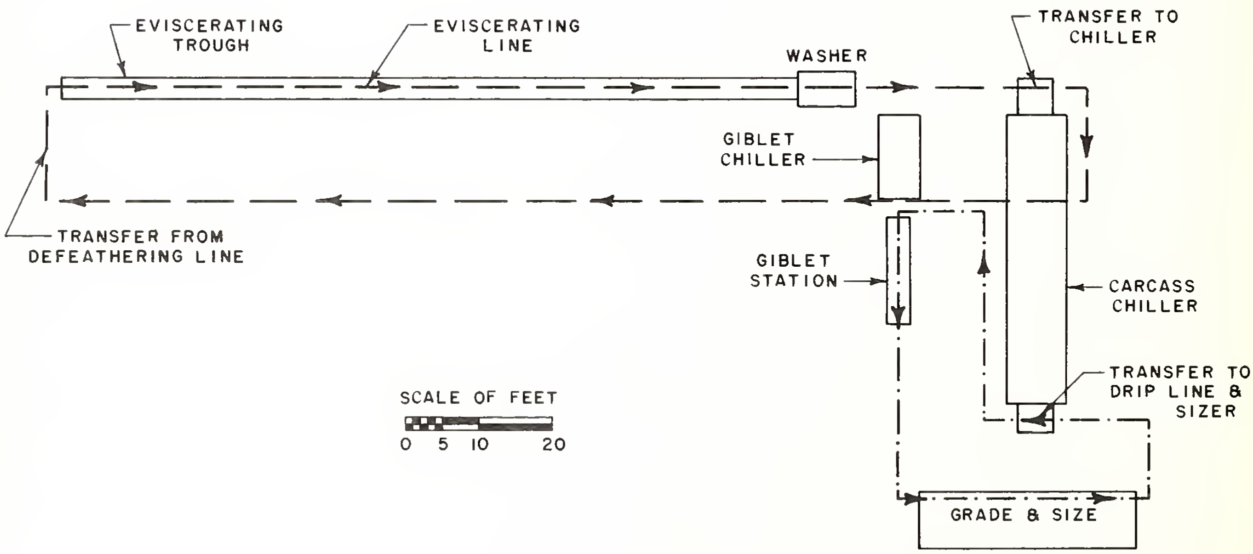

FIGURE 22.—The arrangement of equipment must be considered in designing the eviscerating and chilling area of a poultry-processing plant. In this layout, a long, narrow, L-shaped area is formed by placing the chiller and other equipment perpendicular to the straight eviscerating trough.

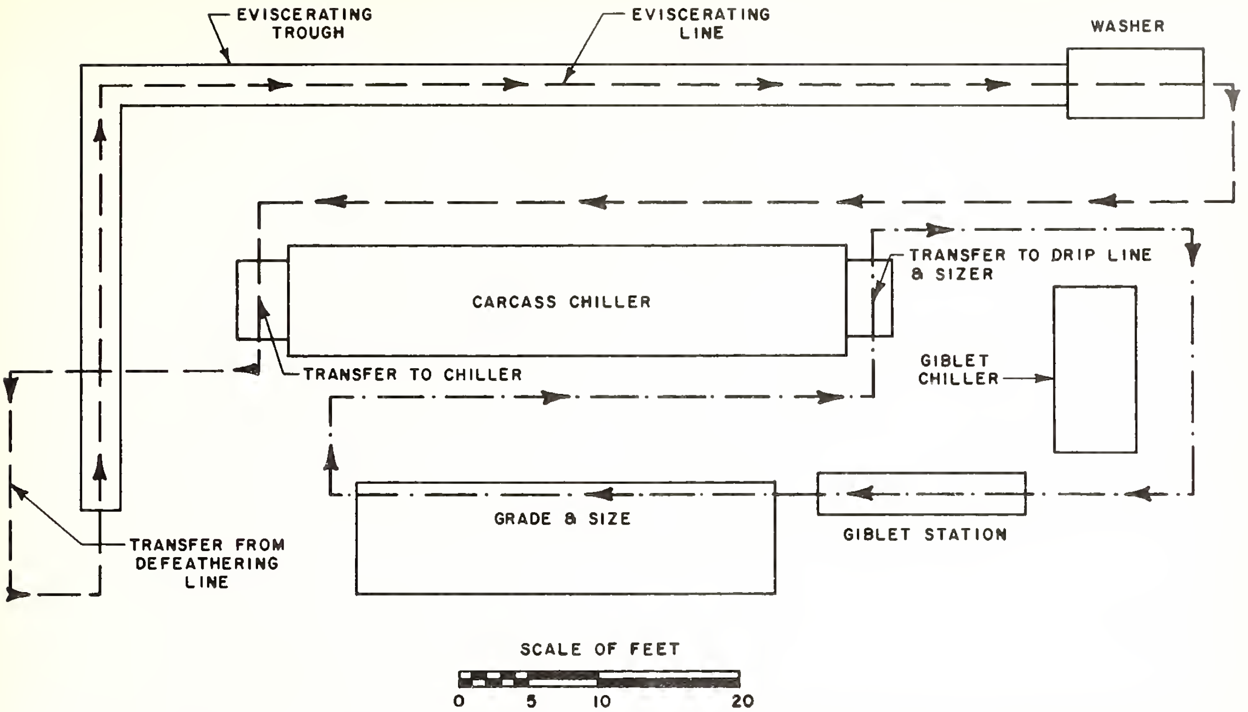

FIGURE 23.—This layout of an eviscerating and chilling area in a poultry-processing plant was designed to accommodate an L-shaped eviscerating trough. The trough, chiller, and other equipment is arranged in such a way that the area forms a relatively compact rectangle.

PACKING AREA

The packing area, which adjoins the eviscerating area, must contain space and equipment necessary for carcass sizing, packing, icing, weighing, and lid closing, as well as space for conveyors to and from the area.

Figure 24 illustrates the layout for a packing area and shipping dock suitable for a medium-size plant (Plan A, fig. 5). The conveyor line from the chillers is routed over the packing bins. The carcasses are mechanically sized while passing over the bins, and are then dropped into appropriate bins for packing.

Packers receive empty boxes from the top level of a bilevel conveyor fed by gravity chute from the box makeup room on the second floor. Sections of roller conveyor between packing stations can be moved back and forth between the various bins, enabling workers to engage in continuous packing of all sizes of carcasses. Full boxes are conveyed on the lower level of the bilevel conveyor to the weighing, icing, and lid-closing stations, and then on to the shipping dock or cooler.

Containers for ice-packed poultry are normally received, stored, and assembled in a space separate from the packing area. Box-storage and assembly rooms located on the second-story level use the gravity chute to deliver the containers to the packing area.

In the expanded layout of the packing area and shipping dock (fig. 25), the most significant change is the additional drip-sizing line routed over the packing bins. Most of the facilities shown in figure 25 will accommodate the additional production, but more personnel will be required for the packing operation.

Further Processing

Space has been set aside in the layout between the packing area, shipping dock, and freezer for a cut-up and packaging operation. Processing equipment is not included because of the many different types of equipment and layouts that can be used.[8]

The further-processing area and the adjacent freezing and frozen-storage facilities are included to demonstrate how they might be located in relation to the other plant facilities. With the arrangement indicated, a part of the plant production can be diverted to further processing. By locating the area convenient to the packing and grading stations, the birds marked for further processing

[8] Research in this area was initiated in 1969.

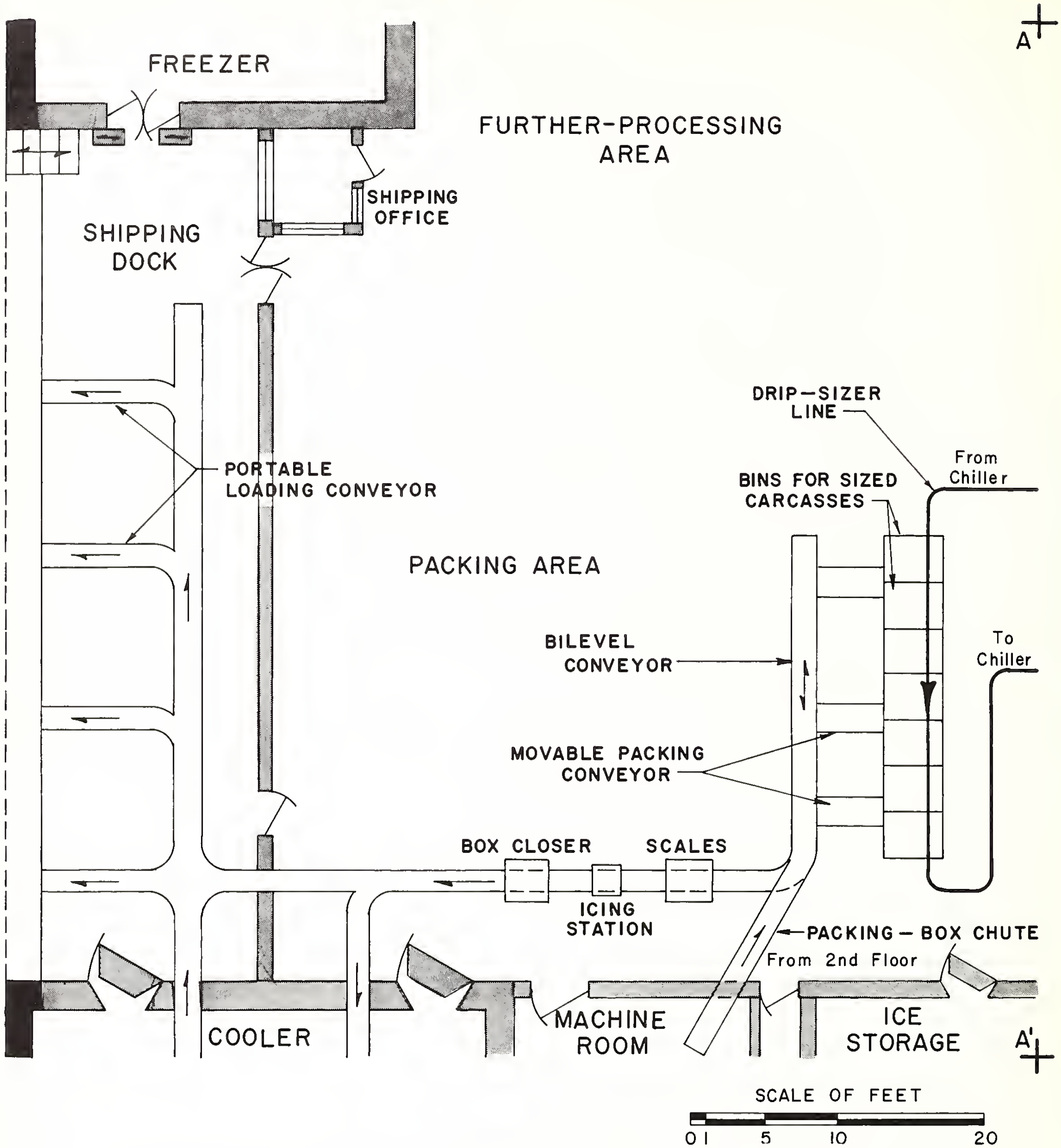

FIGURE 24.–Layout of packing area and shipping dock for model poultry-processing plant. A complete layout of the plant (Plan A) is shown in figure 5.

can be moved by conveyor or chill tank to a cut-up station, then packaged, frozen, and shipped. The size of the further-processing area, freezer, and holding room depends upon the extent of the further-processing operation.

Shipping Dock

Ice-packed poultry is usually shipped immediately after processing and packing. It is moved directly into trucks from the packing area, the top of the load is

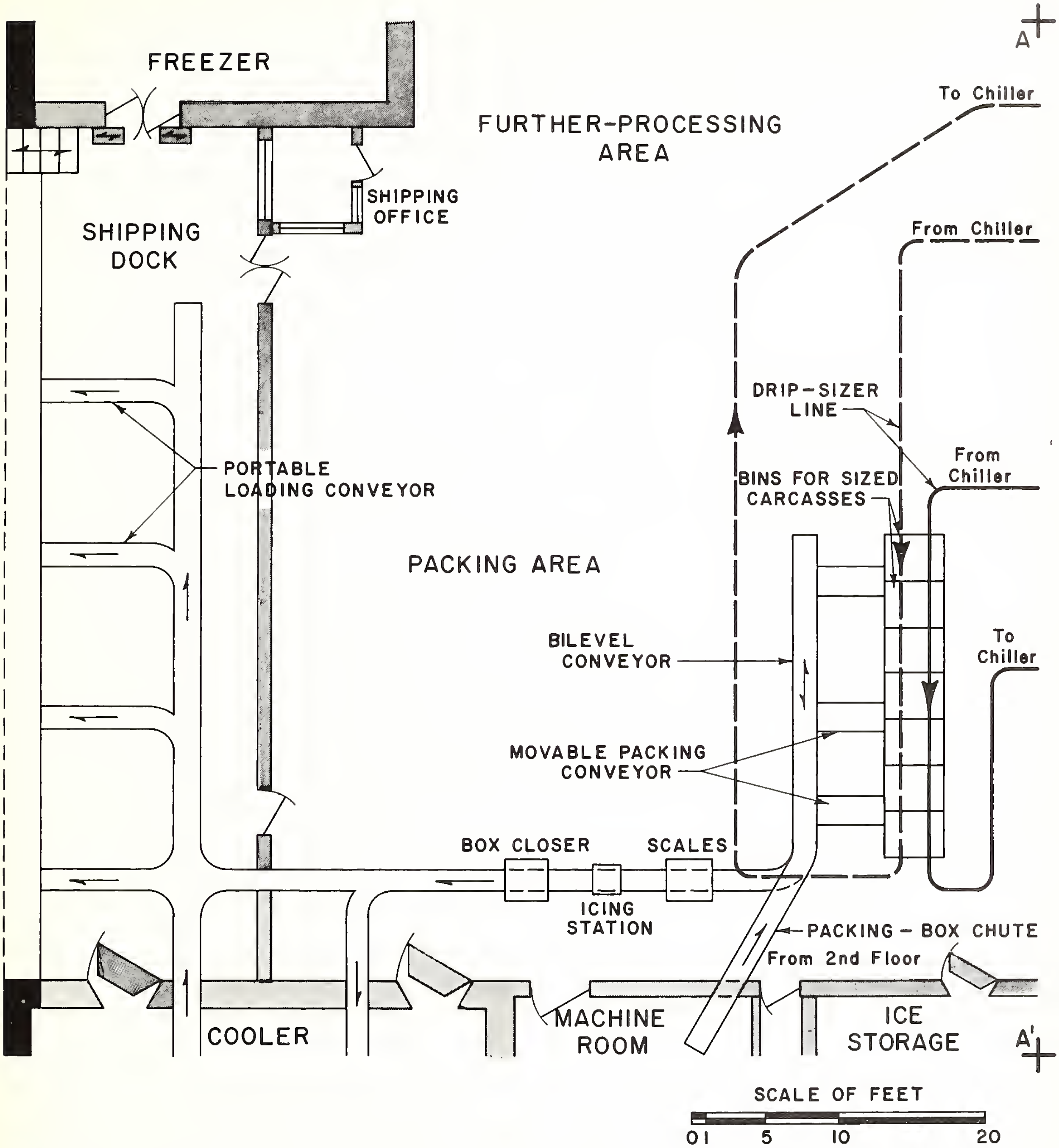

FIGURE 25.–Layout including expansion details for packing and shipping area of model poultry-processing plant (Plan B, shown in fig. 6). With more employees added for the packing operation, the expanded area is able to accommodate 9,600 birds per hour.

capped with crushed ice for additional refrigeration, and the shipment is ready for transport to a distant market. Boxes that are not shipped immediately are temporarily placed in the plant's refrigerated storage.

Loading-area layouts and procedures varied so much among case-study plants that a standard layout for all plants was difficult to develop. Variations were frequently caused by differences in chilling methods and load composition (variety of bird sizes). However, although plant requirements for shipping-area layouts differ greatly, some basic layout principles can be employed that will benefit most plant operations.

Location of the shipping dock is normally near the packing area and cold-storage rooms so that minimum distances are required for moving the packaged products. When the plant faces a main highway or thoroughfare, it may be desirable (for good appearance) to locate the shipping dock at some place other than the front of the building. This requirement also applies to buildings with fronts so close to the main road that interference with road traffic is encountered. The location of the shipping dock should also permit future expansion of the dock and truck areas.

Width of shipping docks in case-study plants ranged from 6 to 22 feet, with most measuring between 8 and 16 feet. Dock lengths varied from 26 feet in a small plant to over 100 feet in several large plants. Dock-edge heights were usually 48 to 51 inches above parking aprons. Studies indicated that if fork-lift transport is used for handling materials, the dock should be at least 14 feet wide. If unit loads are moved about by two-wheel handtruck, manual hydraulic low-lift platform truck, or by portable gravity conveyor, a 10-foot width is sufficient.

The dock length should be designed to accommodate the number of trucks and loading equipment required to handle peak shipping loads. The dock frontage allowed for each truck should be set at 12 feet (fig. 26). The dock should be free of columns where width and building construction permit, but if columns are necessary, placing them on 24-foot centers along the outer edge of the dock will allow spaces for two 12-foot trucks between each column.

Guidelines painted on the face of the dock and on the apron will aid drivers in backing trucks into position. Adequate space must also be provided in front of receiving-dock aprons and truck-parking areas to permit trucks to maneuver into and out of such areas (table 1). Table 1 indicates that as the width of the dock space allotted to a truck of a specific length increases, the required maneuvering space decreases. Maneuvering space must be sufficient to accommodate trucks with the largest turning radii (fig. 26).

If large and small trucks are to be accommodated at the same dock, one or two truck aprons should be sloped to accommodate the smaller vehicle(s). A slight difference in truck-bed height can be overcome by using a dock board. Truck beds of tractor trailers vary in height from about 46 inches to over 56 inches, and may be 6 to 8 inches higher when empty than when loaded. Dock height is not as critical when conveyors only are used for loading. When forklift trucks are used, dock plates, adjustable dock boards, or equipment for raising or lowering the truck are necessary. If for some reason the dock cannot be constructed at the required height in relation to the truck apron, it may be possible to obtain the correct height by ground excavation and sloping the apron toward the dock. However, steep inclines should be avoided to prevent trouble from shifting cargo and loss of traction in cold weather. If the apron slopes toward the dock, drains must be provided near the dock edge.

A glass-enclosed cubicle large enough for a bookkeeping desk and stool is all that is needed for a shipping office. It should be located so it will command a view of the shipping dock and the packing area.

Dock surfaces should be reinforced concrete sloped at least one-fourth inch per foot for drainage, with a surface finished to provide adequate nonskid and wear-resistant qualities. Floor-load capacity will depend upon handling methods and equipment used. Bumper guards should be provided to protect dock edges and trucks. Although guards made of heavy timbers are widely used, rubber bumper guards provide good shock-absorption qualities and wear resistance. If the dock is completely enclosed, a bumper cushion should be installed around the entire door opening.

Ceiling height of the dock roof will be determined by the types of handling equipment that will be used and on ceiling height of adjacent areas. A ceiling 12 feet above the dock surface is the minimum height for forklift truck operations. A roof overhang of 3 feet should be provided for weather protection and gutters should be installed to carry water runoff away from the bodies of the trucks. At least 14 feet of clearance must be provided between the surface of the truck apron and the roof overhang.

A minimum light intensity of 10 foot-candles should be available on the shipping dock, although higher intensities may be desired at locations where box weights are checked and shipping records maintained. If extensive night operations are contemplated, adjustable spotlights for lighting truck interiors will be needed. Several weatherproof electrical outlets for portable tools, as well as outlets for drinking and cleanup water, should be provided. Open shipping docks cannot be heated, but portable heating units should be available. In extremely cold areas, an enclosed shipping dock, with overhead or sliding doors at truck positions, is necessary.

Boxes of ice-packed poultry are usually delivered to the dock by a powered belt, roller conveyor, or combination of powered and gravity conveyors. When only one truck is to be loaded, the conveyor can be routed directly into the truck. However, when several

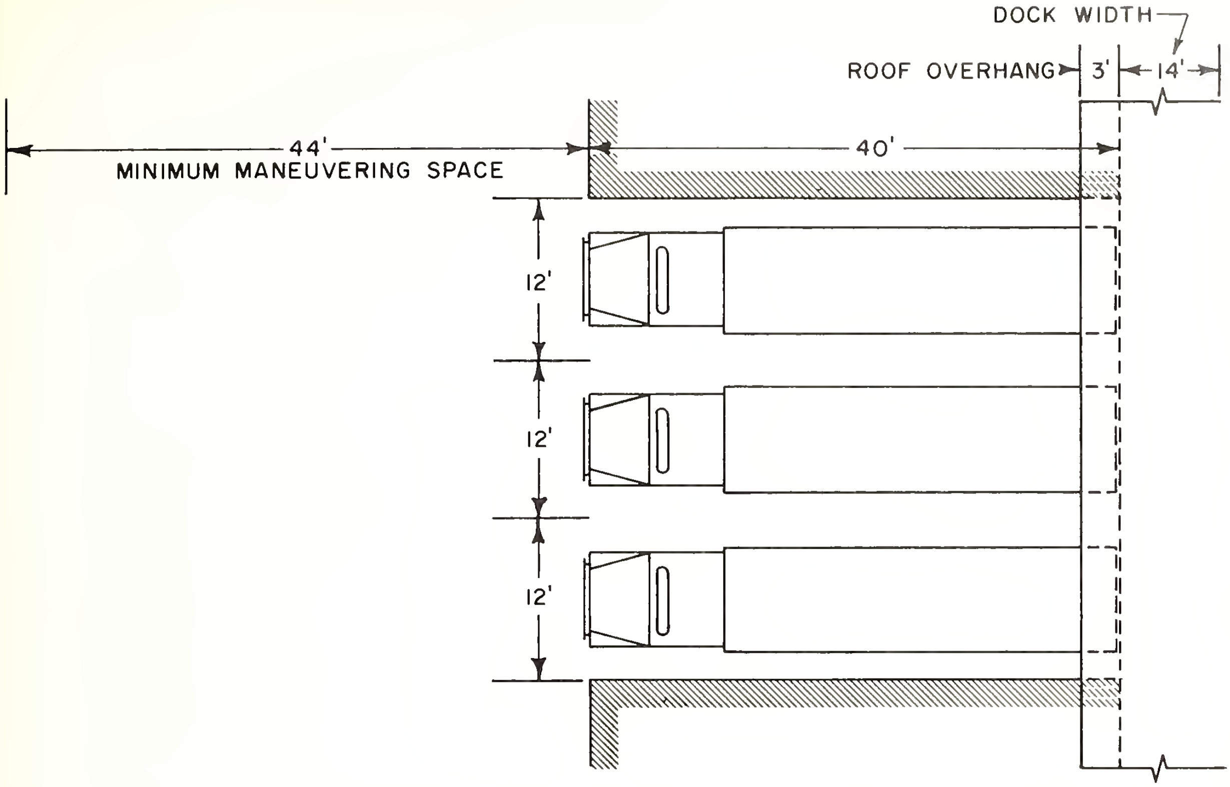

FIGURE 26.–Recommended dimensions for minimum dock, truck bay, and maneuvering area in a poultry-processing plant.

Table 1.–Minimum apron space required to maneuver tractor trailers of specified lengths into dock spaces 10, 12, and 14 feet wide[1]

Length of tractor trailer	Width of allotted dock space	Minimum apron space required
Feet	*Feet*	*Feet*
40	10	48
40	12	44
40	14	42
45	10	57
45	12	49
45	14	48
50	10	[2]70
50	12	[2]60
50	14	[2]56

[1]Figures obtained from tests conducted by the Fruehauf Trailer Company with standard equipment handled by experienced drivers able to back into position in one maneuver.
[2]See *(7)*.

trucks were loaded simultaneously, most of the plants included in the study switched or shifted the boxes from the delivery conveyor to portable wheeled conveyor sections leading to the individual trucks (fig. 27). These

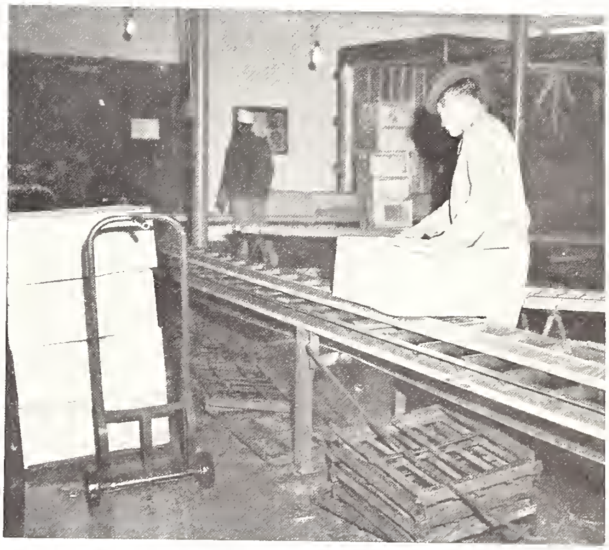

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FIGURE 27.–Boxes of processed poultry being delivered on a powered roller conveyor to the plant's shipping dock. The boxes will be transferred to portable gravity conveyors routed into waiting trucks. The small lot of boxes shown at the left were moved into position by handtruck and will be used to complete the truckload.

portable conveyor sections were lightweight, were equipped with such accessories as height-adjustment devices, and included curved sections and switch sections that permitted many different box-routing arrangements.

After the truck is loaded, crushed ice is sprayed over the load (fig. 28). The amount of ice used in the plants observed varied from 1,000 to 4,000 pounds, depending upon the truck size, amount of insulation, season of the year, and length of trip. Observed methods of icing trucks included: (1) Shoveling ice by hand from a portable ice bin, and (2) blowing ice into the truck through a rubber hose attached to a mechanical blower or combination crusher-blower. Some plants iced the trucks at the plant, and others sent the trucks to commercial ice plants. The icing method selected should be based on the comparative costs of plant-manufactured and commercial ice.

BN-32425

FIGURE 28.—Top icing a truckload of ice-packed poultry.

STORAGE AREA

Storage facilities did not vary greatly from one plant to another in the type of processing operation studied. The volume of product processed and the form of the final product influenced the type, size, and sometimes the location of storage areas. These areas were divided into the three basic storage categories: Nonrefrigerated (dry), refrigerated cooler, and freezer.

Nonrefrigerated Storage (Dry)

Dry storage is primarily used for packaging materials. It can be an uncomplicated area when the product requires only one type of container, as when the entire plant output is ready-to-cook, ice-packed chickens. However, all aspects of dry storage, including inventory control, materials handling, and capital investment, become more complex and more difficult as plant volume increases and the final products form becomes more diversified.

Packing boxes are almost always assembled in the storage room and conveyed to the packing station. For this reason, the dry storage area and the packing area are usually adjacent. Exact dimensions cannot be prescribed for a box storage and assembly room, even for a specific volume and type of plant output, because of varying box-delivery schedules, procurement policies, and differences in plant operating methods and shipping schedules.

A second-story box-storage and assembly area has two advantages. It can use gravity for conveying boxes to the packing stations, and it can make use of such space as that above cold storage and machinery rooms, which is not normally used or is not well suited to processing operations (fig. 29). In order to exploit the advantage of second-story space, a portable elevator conveyor must be used to move packing materials from the supply truck to the storage space.

Box-room location and construction should be planned so that future expansion can be accomplished at minimum cost for either increased production or diversification in packaging. If box rooms are located over processing areas, floors must be dusttight. Several windows are recommended for providing ventilation and natural lighting. Utilities required include: Artificial lighting for approximately 5 foot-candles in storage areas and 20 foot-candles in the box-assembly area, power outlets near the receiving portal and others near the work stations for packing-materials makeup, and a unit heater and fan for heating and ventilating the area.

If the box-assembly equipment is placed near the middle of the storage room and box material is stacked on both sides, handling labor can be reduced.

Refrigerator-Cooler Storage

Normally, whole, ice-packed chickens are shipped on the same day they are processed; however, if any of the iced containers must be held, they should be stored at a

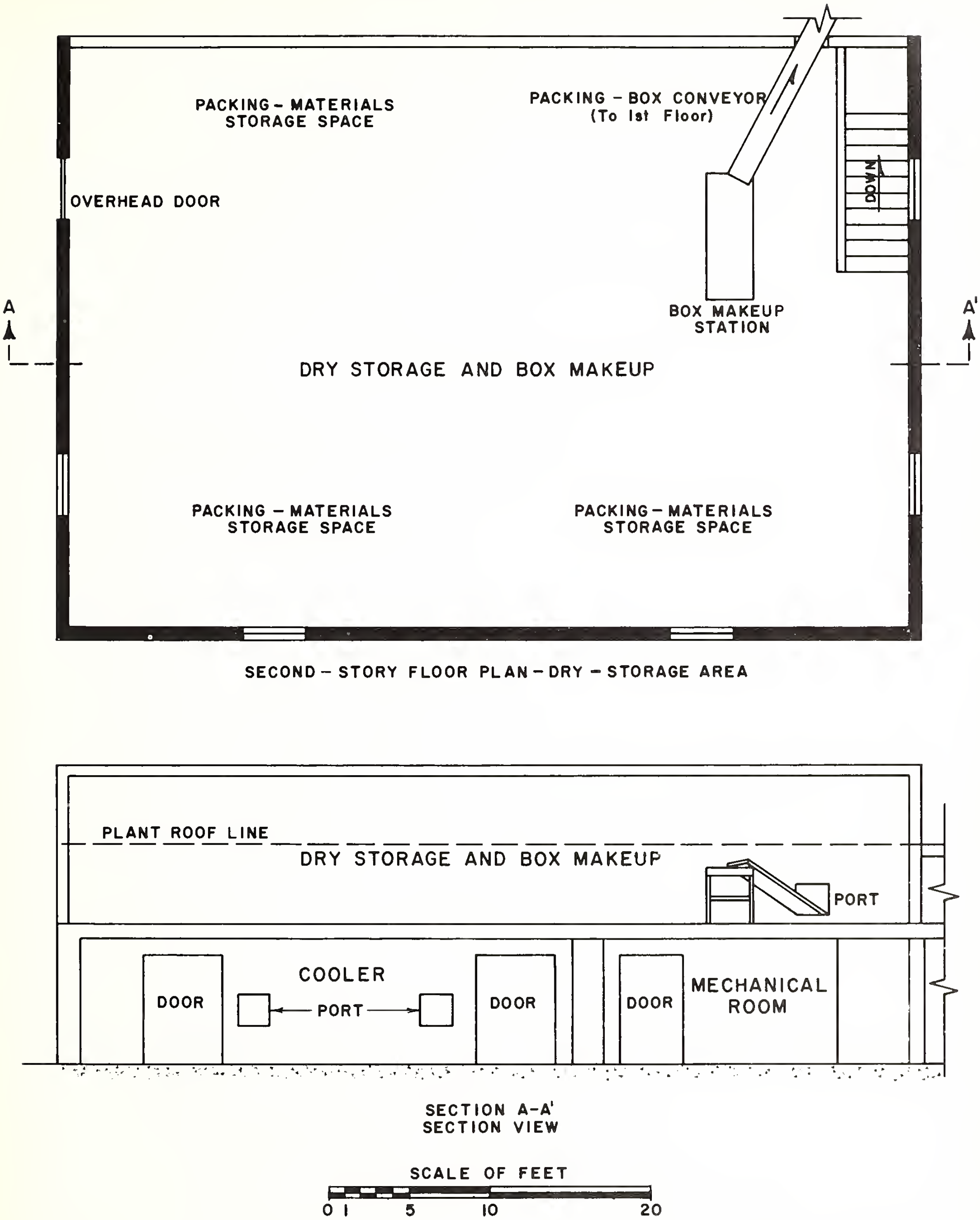


FIGURE 29.—Cross-sectional schematic showing box-storage and assembly room located above cold-storage and machinery rooms in a poultry-processing plant. The area selected for storing and assembling boxes is suitable for use by both a plant with medium production capacity (Plan A, fig. 5) and a plant with large production capacity (Plan B, fig. 6).

temperature of 32° to 36° F. In some of the processing plants studied, the coolers were located directly between the packing area and the shipping dock, and all packed product was conveyed through the cooler. Containers

that were to be stored temporarily were removed from the conveyor and stacked in the cooler while the rest continued to the shipping dock.

The practice of routing all containers through the cooler is questionable because it requires that a worker be present in the cooler at all times even though most of his work time is spent in waiting. This practice also increases the power consumption of the refrigeration equipment. A more desirable method provides for separate shipping and storage conveyors, or for switches allowing selective routing of the packed product. When the need for temporary cooler storage is infrequent or the amount of product to be held over is small, consideration should be given to using handtrucks for moving the product into position in the storage cooler.

Some large plants move all boxes from the packing area to the shipping dock or cooler by rider-type forklift trucks or walk-type pallet transporters. Location and size of the coolers and cooler entrances should be planned so that the cooler area will readily accommodate various types of materials-handling equipment and operational systems. Such planning will facilitate efficient movement of product directly to the truck dock without interference to product moving in and out of the cooler.

The amount of cold-storage space that will be needed in a processing plant preparing whole, ice-packed chickens is difficult to predict with accuracy because production rates and shipping schedules differ between plants. This variance is reflected in the sizes of coolers observed in seven plants having an hourly production capacity of 4,800 to 6,000 birds. The average cooler space was 1,100 square feet, with individual cooler sizes ranging between 450 and 1,700 square feet. Five of these plants also had freezing facilities. In five large plants having an hourly production rate of 9,000 or more birds, cooler size ranged from 912 to 2,842 square feet and averaged 1,450 square feet. Two of these plants also had freezing facilities. Regardless of individual plant variables, cooler facilities capable of holding at least 1 day's production is good insurance against an emergency.

The height of cooler ceilings in case-study plants varied from 8 to 14 feet, with 8 to 10 feet being the most common. Since storage in coolers is temporary and the quantity handled does not ordinarily warrant high stacking, an 8- to 10-foot ceiling is adequate.

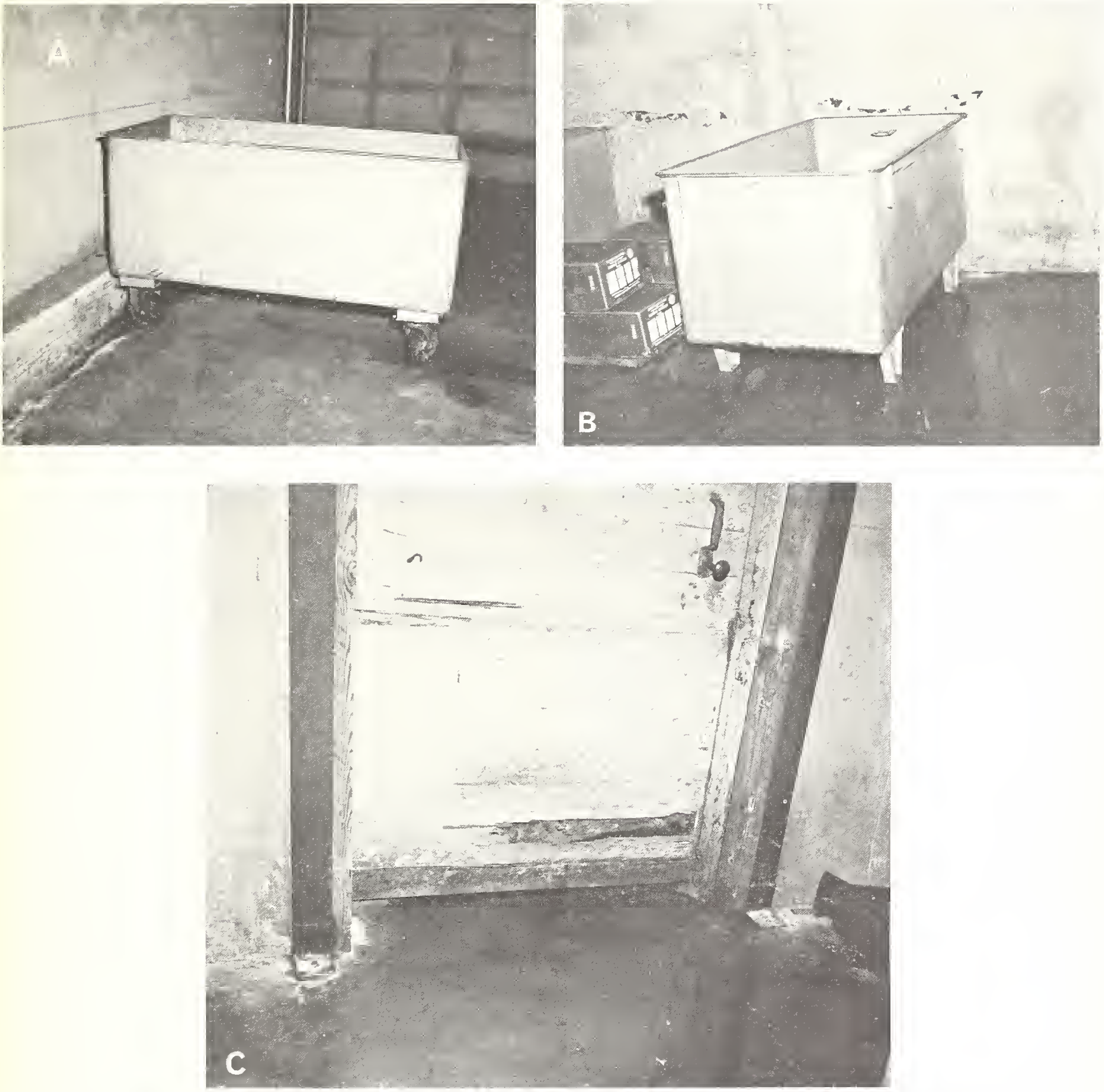
Design and construction of cold-storage rooms require special materials and techniques and should be entrusted only to those experienced in this field. Some of the features that require extra care and consideration are: (1) Structural materials used; (2) installation that provides protection from moisture and mechanical damage (vapor barriers are normally installed on the warm side of the insulation to keep out moisture, which reduces insulating qualities and causes deterioration); (3) insulating material of type and thickness that provides the best economic balance between cost of insulation and cost of refrigeration; (4) foundations capable of supporting maximum floor loads; (5) floor construction that provides adequate drainage for ice-water runoff; (6) 6-inch curb on inside walls to facilitate air movement around product (fig. 30 *A*) and to prevent equipment damage to walls (fig. 30 *B*); and (7) durable door and threshold construction that minimizes physical damage by materials-handling equipment (fig. 30 *C*).

Other design factors to be considered include: (1) Aisle widths for rider-type forklift-truck operation should be at least 10 feet; (2) aisle widths for walk-type pallet transporters should be at least 8 feet; (3) aisle widths for two-wheel handtrucks and worker foot traffic should be at least 4 feet; (4) space between ceiling and top of stacked packages should be at least 2 feet; (5) space between walls and packages and between stacks of packages should be at least 6 inches; (6) stacked packages that are not palletized should be elevated at least 4 inches off the floor; and (7) cooler doors should be at least 12 inches wider than the widest load that will pass through them.

The capacity of the refrigeration equipment needed to maintain the cooler room at the required temperature depends on the outside air temperature; the heat-transfer qualities of the walls, ceiling, and floor; the refrigeration load created by stored product, refrigeration loss and heat gained through the cooler door or through other cooler openings used for transfer of the product; and the heat produced in the cooler by electrical equipment and employees. Most of these factors vary greatly from one plant to another; thus detailed calculations by a qualified engineer are necessary to set up refrigeration requirements for each plant.

Freezer Storage

Freezer storage facilities consist of two components, each of which requires a separate room: (1) A blast freezer operated at temperatures of -20° to -60° F. to freeze the product rapidly, and (2) a room held at 0° for storage of the frozen product. The product is normally transferred from the blast freezer into the holding room after it has been packed in master containers. A common



BN-32486, BN-32491, BN-32488

FIGURE 30.—*A*, A curb is used inside this plant's cooler to prevent equipment from damaging the walls. *B*, Such damage reduces the effectiveness of the cooler's insulation and causes deterioration from moisture penetration. *C*, Equipment damage to the cooler door will also cause deterioration.

refrigeration-equipment room for the two freezer components is most practical. Commercial blast freezers are available that come as complete units with freezer, storage, and equipment rooms.

Blast freezers are not used for high-stacking the product; therefore, the ceiling height is normally 8 to 12 feet. The product is usually frozen in a rack of some type (fig. 31) that remains on a pallet or semilive skid during the freezing operation.

Frozen products are packed in 1-, 2-, or 5-pound packages that are packed in master cartons before being stored in the holding freezer. Pallet loads (fig. 32) are frequently high stacked, requiring ceiling heights of up to 20 feet. Pallet racks of structural steel can be used to

BN-32473

FIGURE 31.—Freezer racks used in blast-freezing operation.

BN-32463

FIGURE 32.—Cartons of frozen poultry in unit loads on pallet racks in cold-storage warehouse.

provide air circulation space between stacked pallets and allow for a "first-in, first-out" inventory-control system. This method of stacking also prevents excessive weight being placed on individual cartons. However, the load-supporting capacity of the freezer floor must be greatly increased to withstand the thrust at the points where the pallet rack legs are supported.

One of the major problems involved in refrigerated cold storage concerns the entrance door to the room. Temperature difference between inside and outside air causes cold air to spill out and warm air to rush in while the door is open, resulting in loss of refrigeration and entrance of moisture. Properly designed and maintained freezer doors should provide smooth traffic flow and keep loss of refrigeration to a minimum.

Mechanically operated freezer doors are generally used when power-driven trucks transport the product in and out of storage. When small lots of product are handtrucked or conveyed into small freezers or holding rooms, hand-operated doors are most economical. However, when a large amount of labor is required or refrigeration loss is high because of opening and closing doors, a power-operated door soon pays for itself. Power-operated swingout doors or biparting doors are available for inplant installation. Vertical-opening doors for loading directly from freezer wall portal to truck are also available, but this type of door is seldom required in connection with freezer facilities in poultry-processing plants.

As a safety precaution, at least one door on every freezer should include an inside manually operated safety release to prevent accidental entrapment of workers. An alarm system that can be set off from the inside is also a practical safety precaution.

The amount of moisture in the room or area adjoining the cold room should determine the type of vapor barrier used on the door. Moisture in the atmosphere will be driven into a wooden door by the differences in temperatures inside and outside the cold room. Once moisture enters the door, rapid deterioration of the wood begins and swelling and buckling cause the door to lose its alinement. Thus, doors opening into areas of high moisture content, or into areas where the walls and equipment are washed frequently, should have sealed metal covers to prevent moisture from entering the wood.

Some refrigerator doors appear to have all parts metal clad, but the bottoms are generally exposed wood. If floors are continuously wet in the area into which these doors open, the addition of waterproof boots will prevent moisture damage. A further safeguard should be used on freezer doors when the metal covering for protection against moisture penetration is a thin sheet, because the thin metal will not protect the door against collision damage by materials-handling equipment (fig. 33). In order to avoid this type of damage, heavy-gage metal kick plates are required as auxiliary covering for

areas exposed to sudden impact from materials-handling equipment.

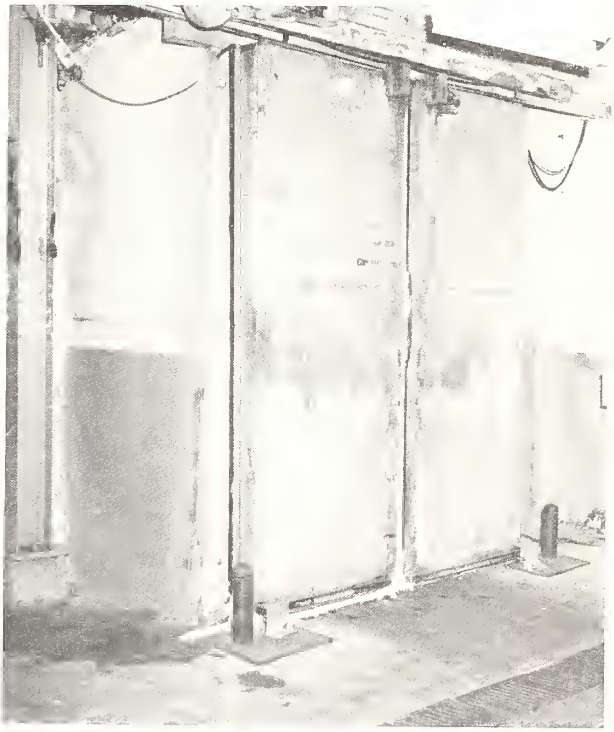
Freezer doors should be installed by skilled specialists according to the manufacturers' recommendations. Proper alinement and a good fit help to keep maintenance low and prevent air leakage, which frequently seals the door when moisture in the air freezes (fig. 34). The gasket is usually damaged when ice-jammed doors have to be forced open. A heated gasket suitable for use on refrigerator doors should be installed to avoid this condition.

Double swinging doors, auxiliary to the regular insulated doors, were observed in several plants. This vestibule arrangement prevents undue loss of refrigeration when the heavier main doors are open. Air doors (or curtains) that provide a high-velocity curtain of air across the entrance of refrigerated spaces are another method for preventing refrigeration loss when the main doors are open. Air doors were not observed in cool-storage rooms, but were in use in several plants in the frozen-storage rooms. Air curtains are placed both inside or outside the cold room, according to the type of equipment used and the design of the cold-storage door. However, experience has shown that inasmuch as air-curtain fans often ice up and become inoperative when placed inside freezers, they generally function most satisfactorily when mounted outside the freezer door (fig. 35).

Although air curtains do not completely eliminate the transfer of heat to the freezer, they do have advantages such as: Restricting the amount of outside air entering the freezer, which helps to maintain the desired temperature within the room when the door is open; eliminating fogging and related poor visibility; reducing the power required to operate the compressors; reducing the amount of coil frosting caused primarily by moisture brought in with outside air; and reducing labor and maintenance costs, savings effected by the elimination of continual opening and closing of doors. Room size, door size, and the frequency of movement into and out of the rooms will determine, to some extent, the feasibility of using air curtains.

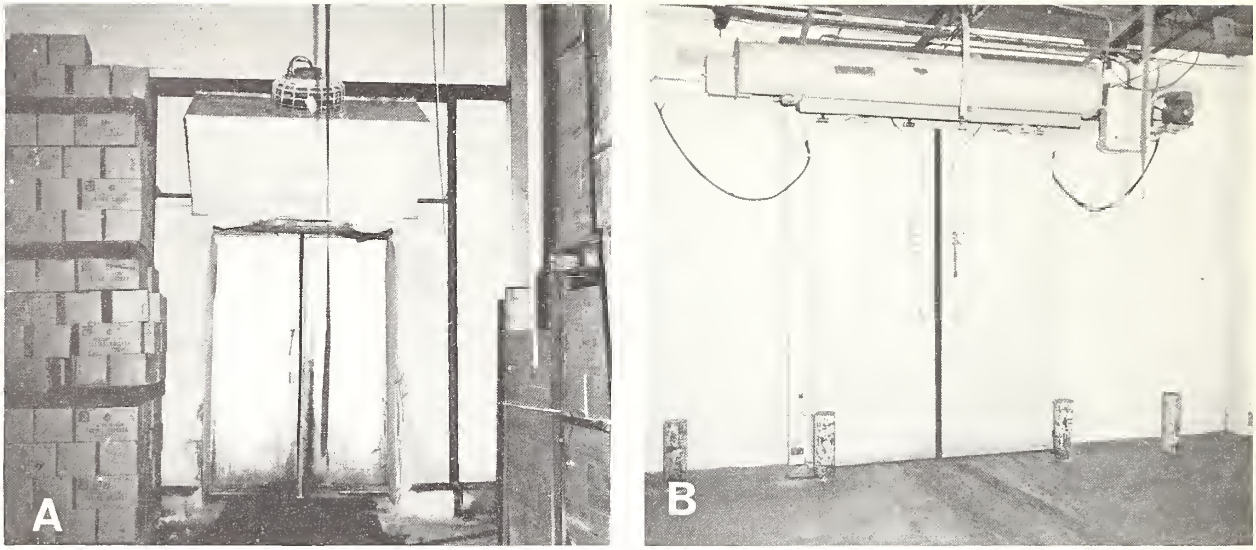
BN-32467

FIGURE 33.—Thin metal sheet applied to refrigerator door in cold-storage area is an effective vapor barrier but will not protect against collision damage.



BN-32468

FIGURE 34.—Ice accumulates around freezer door when improper fitting allows air leakage.



BN-32476, BN-32466

FIGURE 35.–Air-curtain equipment prevents refrigeration loss most effectively when it is placed outside the freezer: *A*, Equipment mounted inside this freezer is inoperative because of frost deposits; and *B*, equipment mounted outside this freezer activates an effective air curtain.

AUXILIARY FACILITIES

Personnel Facilities

In recent years greater emphasis has been given to providing plant workers with more comfortable personal facilities. These have contributed to greater worker productivity, improved workmanship, better morale, and lower labor turnover. Clean lunchrooms and washrooms, and adequate toilet and parking facilities in modern plants reflect management's concern for a sanitary operation and employee welfare.

Lunchrooms

A wide range in the size of employee eating facilities and the type of services provided was found in the case-study plants. Facilities and services ranged from cafeterias that served hot meals and occupied up to 2,200 square feet of floor space, to small rooms equipped with tables and chairs only in about 450 square feet of space. Between these extremes were plants equipped with snack bars that provided limited food service and other plants that had vending machines that provided either snacks or complete lunches (fig. 36). Providing food services through vending machines is an effective way of insuring adequate service while relieving management of many of the problems of maintaining and servicing a public eating establishment.

BN-32479

FIGURE 36.–View of a lunchroom showing a good table-bench design and economy of space in the use of food, drink, and candy vending machines.

The question of whether employee eating facilities should be provided necessitates an important managerial decision. Some of the factors that should be considered are: (1) Plant size and number of employees, (2) plant location in relation to employee residences and commercial eating establishments, (3) cost of equipment, (4) availability of space, (5) availability of vending-machine service, (6) plans for future expansion, and (7) extent of beneficial effect on employee morale.

One authority on public eating facilities suggests 15 square feet per person be provided for cafeterias and restaurants (*10*). This is much more space than was allowed in the poultry-processing plants studied, where the space for such facilities averaged about 6 square feet per person.

Federal and most local regulations require that eating facilities be located in an area away from poultry-handling areas. Locating lunchrooms near the washrooms and convenient to major work areas reduces plant pedestrian traffic as well as time away from the employee's work station.

Washrooms

The term "washroom" is considered to include locker-room or clothes-changing areas, lavatories, and toilet facilities. Regulations[9] prescribe the minimum number of toilets and other requirements for this area in processing plants. It is also advisable to consult with local health authorities on washroom regulations to insure compliance with local requirements.

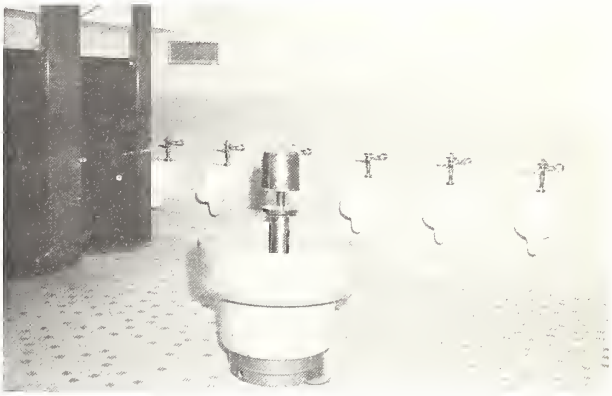
Washrooms for the labor force in most plants studied were usually located near (but separated from) the eviscerating area, where most of the employees worked. Rooms for men and women were also usually located side by side so that a simpler and more economical plumbing system could be installed. In large plants, particularly those with large further-processing operations, washrooms were provided in several locations to reduce the walking distance. Separate facilities should be provided for office personnel.

Important considerations for layout and design of washroom facilities are: (1) Complying with Federal, State, and local regulations; (2) selecting locations that minimize walking distances and the need for complex plumbing installation; (3) including sufficient space for workers to store personal belongings, including hanging space for coats; (4) providing for plant expansion by allowing for additional washroom space and by installing rough plumbing connections in the original construction; (5) selecting building materials for, and constructing floors, walls, and ceilings so they will present a pleasing appearance and will be easy to clean and maintain; and (6) providing for an adequate supply and delivery of hot and cold running water, adequate ventilation from fans or from window opening to the outside, and good lighting. In addition, a number of other desirable features, such as tile floors, wall-hung fixtures, and circular foot-pedal-controlled wash fountains (fig. 37), lend themselves to effective sanitation.

[9] Poultry Products Inspection Act, effective January 1, 1959

First Aid

Generally, separate first-aid rooms were provided only in the larger processing plants included in the study. Figure 38 shows a clean, well-equipped first-aid room. In other plants, emergency first-aid supplies were available in the superintendent's or foreman's office.



BN-32464

FIGURE 37.—View of a modern washroom designed for good appearance and minimum maintenance.

BN-32472

FIGURE 38.—A well-equipped first-aid room.

Parking

There is no exact method for determining in advance the amount of parking space that will be required at a plant. Factors such as number of employees, car pools, working hours, plant location, and availability of public transportation and eating establishments affect the amount of space needed. In some case-study plants, the

management provided parking spaces for key personnel only and relied on street parking to serve other employees. In other plants, the management attempted to provide parking space to meet total requirements. In view of the morale factor involved, it is recommended that processing plants attempt to provide adequate parking spaces reasonably close to the plant, including spaces for office personnel and visitors. Standards for parking-lot layouts and requirements have been developed and described (*10*). One writer (*16*) has suggested that the number of parking spaces provided in industrial plant parking lots equal one-half the number of employees on the largest shift. Although it would be desirable to pave parking areas with concrete or asphalt, graveled surfaces are satisfactory if adequately drained and maintained.

Office Facilities

Floor space occupied by offices in case-study plants averaged 7 percent of the total plant area. Reception, administrative, and management offices, such as those allotted to superintendents, inspectors, and foremen, were located near the production areas. The superintendent's office is generally located adjacent to the eviscerating-chilling area and has a large plate-glass window that provides a good view of these areas. Inspectors' offices are usually located near or adjacent to the superintendent's office. The proximity of these offices is logical since superintendents and inspectors frequently confer, and since their principal activities are in the same areas of the plant. Because restroom and locker space must be provided for inspectors, many plants have included a washroom between the inspectors' office and superintendent's office for the convenience of both.

Office facilities requirements are as follows: (1) Adequate sitting room for visitors and a reception center or window near the entrance; (2) private offices for persons whose work requires concentration without interruption; (3) a general office layout for two or more workers with space for files and for frequently used business machines located near the persons who use them; (4) separate restroom facilities for the general office staff; (5) a secure place for office supplies, records, and funds; (6) natural lighting augmented by artificial lighting and a number of electric outlets on each wall for business machines; and (7) provision for expansion and flexibility by the use of nonload-bearing walls or movable, prefabricated sections. The use of prefabricated head-height panels to provide separate offices not only makes changes easier, but also simplifies problems of heating, ventilating, and lighting.

Maintenance and Shop Facilities

Poultry-processing plants can ill afford equipment breakdowns. For example, a breakdown causing stoppage of the defeathering conveyor can result in the loss of those broilers in process and the loss of 3 to 8 dollars per minute in idle labor. To minimize losses caused by such emergencies, an effective preventive maintenance program that includes scheduled inspections, tests, servicing, and repair of machinery and equipment must be carried out. Such a program requires not only competent maintenance personnel, but also adequate shop facilities, tools, and storage space for necessary supplies and spare parts. A properly organized file containing a complete inventory and up-to-date maintenance records of all machinery and equipment should also be available.

Certain features should be incorporated into the overall design of the plant to make maintenance easier. Bonded convenience outlets should be placed throughout the plant so that portable tools can be operated without the necessity of stringing long extension cords; similarly, electric-welder connections should be located in several areas of the plant. A fixed ladder leading to motors or gear boxes in each area of the plant using overhead equipment hastens emergency repairs. Automatic lubricating equipment for overhead monorail conveyors should be used instead of manual lubrication. Enough space should be allowed around each machine so that it can be easily serviced or removed without disturbance to other machines. Painted bands on pipes provide quick identification of each.

Supplies should include a well-arranged stock of commonly used items, such as pipes, pipe fittings and nipples, bolts, screws, washers, angle iron and bar stock, hose fittings, and electrical plugs and fittings. The type and number of spare parts kept in stock will depend on the types of equipment installed, usage data, and proximity of supply houses. Commonly needed items such as picker fingers, shackles, and gizzard peeler rollers should always be stocked, even though a parts supplier may be close by, to avoid line shutdown for extended periods. Spare V-belts for each machine should also be stocked and identified so that belt replacement can be made rapidly. Periodic inspections and replacement of belts while they are still operative will almost eliminate emergency belt replacements. Some processors also find it economical to stock spare motors, for replacements or

for temporary use during the servicing of regular equipment. Bearings units are often stocked for pickers and other high-speed equipment. Suitable outside storage should be provided for paints, oil, grease, and other flammable products.

Maintenance shops are generally simple in layout and contain only a few pieces of equipment. Many shops include only a grinder, drill press, machinist's vise, pipe vise, portable electric and acetylene welders, pipe cutting and threading equipment, a tap and die set, general mechanic's hand-tools, and work benches. Table 2 indicates the amount of space required for each machine mentioned. This space includes a nominal amount of work space for average jobs performed with each of these machines. With small maintenance crews, machine work space can overlap, but not to the extent that work placed in one machine strikes other machines. In addition to space for these machines, an area measuring at least 10 by 10 feet should be provided for fabricating new equipment or for in-shop repair work.

Table 2.–Machine and working-space requirements for various items of plant shop equipment[1]

Shop equipment	Space required
	Square feet
Compressor, air electric, stationary	15
Drill press, 14-inch, with accessories	60
Grinder, heavy duty	50
Hacksaw, electric, with 6-inch stroke	40
Rack, metal (horizontal)	18 to 22
Welding area, electric arc, with all equipment . .	50
Welding, oxyacetylene, with all equipment . . .	50

[1] Harris, R. R. technical recommendations regarding physical facilities for a department of vocational agriculture in Georgia schools. P. 2. Dept. Agr. Engin., Univ., Ga., Athens. 1953. [Mimeographed.]

A set of portable screens should be available to close off the area around the welder to protect other persons in the shop area. It is helpful to locate the shop and storage areas near or adjoining the boiler room so that maintenance personnel can keep a continuous check on the operation of the fixed equipment in these areas.

Shop facilities should also include: (1) Light fixtures providing a light intensity level of 20 to 30 foot-candles throughout the shop area, supplemented by drop lights at work benches capable of raising the light intensity to 50 foot-candles; (2) electrical outlets for all equipment and for portable tools; (3) an exhaust fan for removing fumes during welding operations (unless window openings are available to give adequate natural ventilation); (4) a sink with hot and cold running water; (5) a space heater; and (6) an overhead door to the outside to accommodate equipment units requiring shop repair.

Boiler Room

The boiler is located close to the scalder to reduce the amount of steam piping required, and to minimize heat and pressure loss. It is also located near the machine shop so that maintenance personnel can keep a close check on boiler operation. The boiler room is equipped with overhead doors for entrance or exit of large equipment. It should be large enough to accommodate a 200-horsepower boiler, should one be required for plant expansion.

Refrigeration Machinery and Ice Storage

The refrigeration machinery and ice-storage rooms are located near the packing and shipping area. This location allows ice to be augered directly to the in-line chillers, box-icing equipment, and shipping docks. A stairway adjacent to the machinery room provides access to the dry-storage room and to the icemaking machinery located on the second floor above the ice-storage room (fig. 39).

BN-32474

FIGURE 39.–A view of an ice-storage room. The plant's ice-making machinery is located on the floor above this storage area.

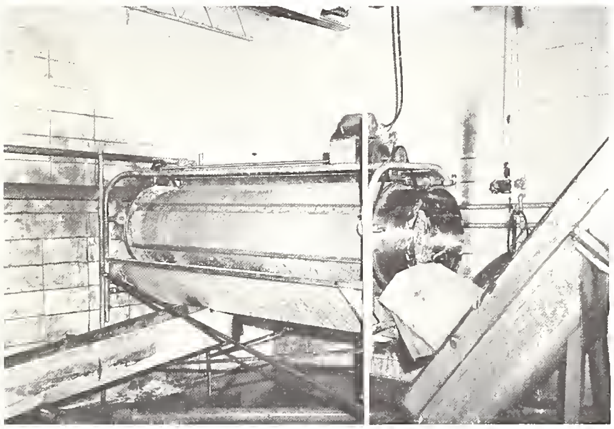
Offal Room

Approximately 25 percent of the live weight of each broiler processed is discarded as inedible material in the form of blood, feathers, viscera, feet, and heads. A plant processing 6,000 3-pound chickens per hour recovers about 4,500 pounds of offal each hour. In addition, a number of condemned whole birds (normally about 1 to

3 percent) and unwholesome parts are discarded and must be disposed of with the other inedible products. Because of the large amount of waste, facilities must be provided for rapid waste removal to prevent creating a nuisance or contaminating edible products.

The offal-room location is adjacent to the defeathering area and near the eviscerating area to keep to a minimum the distances that feathers and offal must be moved (by floor gutter drains). Because most feathers are removed by the first two picking machines, travel distance to the offal room is only a few feet for the bulk of discarded feathers.

Processing plants commonly effect continuous removal of wastes from the scalding, picking, and eviscerating operations by means of gutter drains in the concrete floor. All gutters must be large enough to handle the necessary volume of water and waste and must be slightly sloped for effective movement of waste product. In the plants studied, feather gutters were frequently 18 to 24 inches wide and sloped 1 inch per 50 feet toward the discharge end. Gutter drains for eviscerating areas were usually 12 to 18 inches wide and sloped 1 inch per 10 feet. Drains for feathers and eviscerating areas discharge into separate mechanical separators in the offal room, where the solids are separated from most of the water (fig. 40). Feathers and offal are conveyed from the separators into an awaiting truck (fig. 41 *A*), or into an overhead hopper (fig. 41 *B*) for removal from the plant at regular intervals.



BN-32478

FIGURE 40.–Rotary screen, shown separating waste feathers and floor-gutter drain water, was located in offal room of a poultry-processing plant. Similar equipment (not shown) was also used in the offal room to remove offal from drain water discharged from a separate gutter.

Regardless of whether the waste is loaded into trucks directly from the offal room, or from hoppers outside of the plant, the truck-loading area should be sloped to trapped drains for carrying off seepage and water from cleanups. To conserve fresh water, some of the water from the separators can be recirculated by pump to assist in feather flowaway.

The offal room should be located reasonably close to, but separate from, defeathering and eviscerating areas to minimize transport distances for waste products. The floor level of the offal room must be lower than the processing rooms to permit proper sloping of gutter drains and installation of separators, pumps, and pumping equipment. In addition, these rooms must have: (1) Tight-fitting doors, (2) sheltered and screened truck space, (3) adequate floor drains, (4) good ventilation, (5) floors and walls (to a height of 6 feet)

BN-32477, BN-32482

FIGURE 41.–After solid wastes have been separated from drain water, they are promptly removed from the poultry-processing plant. *A*, In one plant, drained feathers were conveyed from mechanical separator directly into waiting truck. *B*, In another plant, drained feathers and offal were collected in overhead bins outside the building for removal at regular intervals.

that are impervious to moisture, (6) walls (above 6 feet) and ceiling that are moisture resistant, (7) hot- and cold-water outlets (or steam-mixing valve) for cleaning, (8) electrical outlets for portable power tools, (9) lighting to provide 10 foot-candle illumination intensity, and (10) heating facilities for cold weather.

UTILITIES

In this report, utilities are considered to include electricity, water, fuel, ice, sewage, and the installations necessary to handle these services. In modern processing plants where thousands of broilers are processed each hour, it is extremely important that utility installations provide the quantity and quality of services needed for an efficient and sanitary operation.

Generally, the electrical, water, and fuel systems are similar in that wiring and piping must be designed to deliver a certain quantity of the service to each outlet at a required voltage or pressure. Between the sources of supply and the point of use, voltages and pressures are reduced because of wire or pipe resistance. Unless the systems are designed to limit these losses, equipment will not operate at the rated efficiency.

Because of variations in individual plant design, location, equipment, processing rates, and operations performed, no two plants have the same utility-load requirements and consumption rates.

Electricity

Designing an adequate electrical system requires detailed information on the location of all lighting and power outlets, switches, and controls, and on the electrical rating of all fixtures and motors (in terms of wattage or horsepower, voltage, and type and phase of the current). An early decision should be reached in the planning phase as to the size and type of transformer(s) required, the voltage and phase to be supplied to the plant, and the rate schedule that the plant will operate under. Most power companies have a number of different rate schedules based on different types and amounts of power supplied. Selection of the proper type of power supply (voltage and phase) and the most favorable rate schedule will result in minimum costs, not only for the electrical installation, but also for the electricity that will be used. Electrical systems should be designed to meet the requirements of the National Electric Code and local regulations, and all installation work should be carried out by licensed electricians.

Substations should be located as near as possible to the "load center" of the plant, and power and lighting distribution panels and controls should be located as near as possible to the center of loads they supply. This placement will permit minimum length and size of transmission wiring and will reduce losses caused by possible voltage drops.

Plants being designed or modified to include ice-making and freezing equipment with large electric motors (75 hp. and up) can reduce power costs by operating under a rate schedule that considers the "power factor" in the demand charge. This is a factor in alternating current systems by which the volt-ampere load must be multiplied to obtain the actual power in watts. If a high power factor is maintained, the volt-ampere load and demand charge will be minimized. The power factor is kept high if motors of the correct size are used and operated near their rated load, and if capacitors are installed.

Lighting

Worker efficiency and inspection accuracy is greatly affected by the lighting conditions of the work station. In addition, the morale of workers is improved with good lighting. Proper quantity and quality of light is obtained by selecting the proper types and sizes of lights and locating them properly. Painting interior walls and ceilings to increase reflectivity will increase the intensity of illumination. Quality of lighting is achieved primarily by location and by type of reflective devices of fixtures used. Proper initial design and installation of plant lighting by qualified specialists will generally provide the most satisfactory lighting system.

Water

Processing broilers and maintaining sanitary conditions in plants require adequate supplies of potable water for delivery throughout the plant. Current minimums set forth in the Poultry Inspectors' Handbook (*11*) call for at least one-half gallon of water per chicken processed to be added to bird chillers and 1 gallon per 40 birds processed to be added to giblet chillers, with a minimum water overflow of 1 quart per bird per minute from the scalder. Other operations and equipment requiring relatively large amounts of water are boilers, pickers, bird washers, eviscerating troughs, hand-wash nozzles, restrooms, cleanup operations, and refrigeration equipment, including that used for the manufacture of ice. Although water is a relatively cheap commodity,

water bills in large processing plants can amount to several thousand dollars per month.

The two fundamental considerations in laying out a water-supply system are: (1) Using minimum lengths of pipe to service all water-expending equipment and fixtures, and (2) delivering adequate supplies of water at the proper pressure and temperature. As water flows through the system, pressure losses occur during distribution in the piping, pipe fittings, valves, and water meters. For example, a flow of 1,000 gallons per minute through a 6-inch disk-type water meter can result in a pressure loss of 15 pounds per square inch or more.

Pressure losses in piping can be minimized by using the proper size and length of pipe and fittings. In order to deliver the required amounts of water at necessary pressure to the individual pieces of equipment and fixtures, the system must be designed and installed properly. The use of oversize piping will increase the installation cost; however, the use of undersize piping will result in excessively high water velocities and friction loss in pipes, and will reduce the pressure and flow at the outlets. Velocities are normally limited to 10 feet per second to limit pressure loss and to avoid noises and "water hammer" in pipes. Inside surfaces of pipes become rougher with age and diameters are reduced because of scale deposits, rusting, and other factors. The initial design for the piping system should make allowances for pressure losses from aging. If expansion is anticipated, consideration should be given to the problem of providing large enough lines to handle expected future loads.

The exteriors of lines carrying cold water will sweat, particularly in winter months when water temperatures are lower than inside air temperatures. When it is necessary to install such lines over work stations or areas where food products are exposed, the line should be either insulated to prevent condensation or provided with drip pans to catch the water.

Suggested ways for minimizing water consumption include: (1) Relying upon qualified specialists for correct initial design and installation of water and flow-away systems; (2) using hand-wash nozzles along the evisceration line that are adjusted to supply only the amount of water needed (*15*); (3) considering the water-consumption requirements for new types of equipment; (4) inspecting and promptly repairing leaking equipment, piping, hoses, and fittings; (5) indoctrinating employees on water-conservation measures; (6) frequently checking water usage in both processing and plant cleanup operations to discover any increase in consumption that may require corrective action; and (7) turning off the water supply to all outlets not actually being used during processing operations and during shutdown periods.

Fuel

All case-study processing plants used gas as the primary source of fuel for firing boilers but had oil available for use in the event of interruption of the gas supply. Boilers were equipped for quick changeover from gas to oil. Plants obtained gas on interruptible schedules and reported that they had to shift to oil a number of times during winter cold spells, when notified by the gas company of interruptions in their gas service. Gas used for singers and unit heaters was obtained on noninterruptible schedules. Although gas may be purchased cheaper on an interruptible rate schedule, the cost of standby equipment must be included in total fuel-cost calculations.

Ice

Ice used in poultry-processing plants must be made from potable water and handled in a sanitary manner. Plants use ice for: (1) Bird chilling, (2) giblet chilling, (3) holding birds in chill vats pending cut up or other operations, (4) icing shipping boxes, and (5) icing shipping trucks. Many processing plants have icemaking equipment and ice-storage bins.

Processing plants that had icemaking equipment reported that they usually had excess icemaking capacity during cold weather but had to purchase additional ice from other sources during hot weather. There are several reasons for this: (1) Plants normally process more broilers during summer months than during winter months, (2) almost twice as much ice per bird is required in the warmest months than in the coldest months, and (3) ice machines produce less ice during summer months when water temperatures are high. All of these factors are additive and greatly increase refrigeration requirements during summer months. In planning a new processing plant, provision must be made for an adequate supply of ice. If no outside source of ice is available, a large enough ice machine must be installed to meet maximum requirements. When a reliable and economical commercial source of ice is available to supply additional ice during high-usage months, the plants icemaking capability can be less than that required to meet maximum demands. In this case, facilities must be provided for

receiving, washing, crushing, and handling the ice that is bought.

Ice-storage rooms are usually located directly under or adjacent to the icemaking room. When the storage room is under the icemaking room, ice falls by gravity into the storage room, but when the storage room is adjacent to the icemaking room, the ice must be conveyed mechanically from the icemaker to storage. Ice-storage bins should be large enough to hold at least twice the amount of ice the machine is capable of producing in a day. The extra ice accumulated on days the plant is shut down will help somewhat to alleviate shortages that occur during warm-weather months. Walls, floor, and ceilings of storage rooms should be constructed of moisture-impervious material and insulated to reduce melting.

Ice in small sizes (chip and shell) has a tendency to cake or stick together when it is stored because of pressure and melting. Although mechanical bin unloaders are available, none of these were observed in use in the poultry-processing plants studied. In most of the case-study plants, ice was removed by one or more screw conveyors installed in horizontal troughs in the floor of the storage rooms (fig. 42). When this system of ice removal was used, at least one full-time employee had to be stationed in the ice-storage room to break up caked ice and keep the conveyor supplied. Overhead screw conveyors were generally used for delivering ice to bird chillers and the box-icing station. A few plants also used screw conveyors to deliver ice to the vicinity of the shipping dock, where a throwing or blowing device was used for icing trucks.

BN-32490

FIGURE 42.–Screw conveyor in floor of ice-storage room is used to convey stored ice to other plant areas.

Sewage System

During selection of the plant site and planning of the plant layout, consideration must be given to the problem of collection and rapid disposal of water from rainfall on and around the plant and of water and sewage within the plant. Local authorities and codes should be consulted for information on regulations and standards pertaining to disposal systems and plant-equipment installations. Plans for methods and equipment designed to handle waste products such as blood, offal, grit, and feathers, as well as discharge from toilets, can be made only after local requirements are known. The introduction of large amounts of blood and solids, such as fragments of fat and skin, into sewage systems greatly increases the load on disposal plants (*9*). Many cities prohibit the introduction of waste blood from food-processing plants into the public sewage systems. When such prohibitions exist, provision must be made for collection and disposal of the blood. Some localities also require that separator water be strained through fine screens for removal of grit, small pieces of tissue, and small feathers.

In addition to using rotating separators for separating the bulk of the viscera and feathers from the flowaway water, some plants are also equipped with vibrating screens (fig. 43) for removal of smaller particles.

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FIGURE 43.–In processing poultry, vibrating screen (inside housing, arrow) is used to remove small pieces of waste solids from gutter flowaway water as the water leaves the mechanical separators.

General requirements for a correct sewage system include: (1) Adequate floor slope and spacing of floor drains, (2) adequate size and slope of pipes and gutters to handle the maximum runoff load without flooding,

(3) freedom from any sort of obstruction or low place that might cause an accumulation of solid materials, (4) proper traps and vents for all drain lines, (5) proper sealing of inlets to guard against outside line surcharge and vermin entrance, (6) provision for line cleanout in case of clogging, and (7) separate lines for toilet and processing waste.

Expected water-consumption rates, together with data obtainable from pipe-design handbooks and plumbing codes, should be used as guides for determining sizes, slopes, and other features of drainage and disposal systems. The main sewerline should be large enough to handle possible load increases that may be brought about by plant expansion, increase in number of employees, and increase in water consumption. Industry experience indicates that it may be wise to install a sewerline at least 12 inches in diameter for new medium- or large-size poultry-processing plants.

Most processing plants use city sewerage systems. A few are known to have provided their own sewage treatment and disposal systems. One rural plant visited, that processed 6,000 broilers per hour, used a 9-acre oxidation pond for this purpose (fig. 44).

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FIGURE 44.—Oxidation pond used for treatment of sewage and waste from a poultry-processing plant.

Oxidation ponds have proved to be an effective and economical means of treatment and disposal of raw sewage and certain industrial wastes (*1, 6*); however, they must be designed, constructed, and operated properly if satisfactory results are to be obtained. They are particularly helpful in locations not having access to city sewerage systems and locations where adequate land of the right soil composition is available at a reasonable cost.

Heating, Cooling, and Ventilating

Gas or steam unit heaters suspended from the ceiling were the most commonly used heating systems observed in processing areas, and these heaters appeared to be well suited for their function. Models are available with different capacities to meet varying space requirements, and the suspended heaters conserve floor space. Offices in small plants were normally heated by individual gas or electric units and offices in larger plants were usually provided with a central heating and duct system.

Air cooling by means of air-conditioning equipment is usually confined in processing plants to office areas and, possibly, to employee lunch rooms. Cooling in production areas is normally performed only by ventilation and the accompanying evaporative cooling that takes place on wet surfaces. In the eviscerating, chilling, and packing areas, a cooling effect is also obtained from chilling equipment and ice-handling equipment.

Ventilation in most processing plants is provided by intake and exhaust fans, supplemented to a small extent by natural ventilation through screened windows or roof vents.

In poultry-processing plants, the requirements for heating, cooling, and ventilating vary considerably from one plant area to another because of the differences in operations performed, the number of people employed, geographic locations and types of building materials, and structural design. As worker efficiency is related closely to comfortable surroundings, it is important that systems for controlling atmospheric conditions in individual plants and plant areas be properly designed by qualified specialists.

In view of the many variables involved, it is not practical to prescribe specific design requirements for heating, cooling, and ventilating systems for processing plants in general. However, an important ventilating requirement in all poultry-processing plants is for their exhaust systems to be designed to move air from ready-to-cook processing areas toward or through the defeathering and live poultry-handling areas so that any airborne contamination from these areas is directed away from the finished-product rooms.

PHYSICAL PLANT

The physical appearance of operating plants necessarily varies greatly. A perspective sketch of a model poultry-processing plant is shown in figure 45.

Plant Site and Location

As in other industries, the geographical location of poultry-processing plants involves many economic considerations. Any industry has three basic needs: (1) To accumulate its required materials and services in one location, (2) to process the materials into products at that location, and (3) to distribute the products from that location to the intended market. Each of these needs represents a number of costs and the relative importance of each need will vary at different locations. The ideal plant site should be the location where the total cost of the three needs is socially and economically acceptable to the community.

The major factors that should be considered in selecting a suitable location and site for a poultry-processing plant include: (1) A supply of chickens sufficient for continuous and efficient operation; (2) markets within convenient hauling distance for overnight delivery; (3) reliable transportation at reasonable cost; (4) a reliable and stable labor force; (5) adequate and reliable utilities and services, including power, water, fuel, communications, and sewerage systems; (6) a means of disposing of processing waste (either by the plant or an outside rendering plant); and (7) ownership of sufficient land to accommodate buildings, driveways, and parking areas. Generally, a site not less than five times the actual size of the plant facility is considered minimum for meeting these requirements (*8*).

From the standpoint of economy, gently sloping sites with good drainage are preferable to very flat or very steep slopes. A flat site may involve poor drainage and steep slopes require excessive grading, also foundations on filled ground are subject to unequal settling. Topography should also permit future expansion without excessive grading and filling. Soil characteristics should include the ability to support building foundations and provision for good natural drainage.

The total amount spent for a plant site is usually relatively small, compared to the actual facility. For this reason, price should not be considered a barrier until all other factors have been studied and their value to the plant site determined. Land that may be needed for possible future expansion can usually be purchased more cheaply at the time of initial site acquisition than at some future date.

The survey and deed should be checked carefully for accuracy as to location, site size, shape, and dimensions, and any applicable building or other restrictions, right-of-way claims, or easements should be determined. In this connection, applicable state and local codes should be checked for: Zoning limitations, building codes, permits, and license fees. Government agencies and private organizations should be consulted regarding sanitation and health requirements, availability of fire and police protection, taxes and assessments, insurance rates, and labor laws.

Building Costs

Comparisons of building materials and construction costs between locations under consideration should be made and the availability of reliable building contractors ascertained.

The physical building of a poultry-processing plant requires special construction characteristics and materials that differ from most industries. This requirement is caused by the great volume of product processed (over one hundred tons per day in many plants), the extremely perishable nature of the product, the strict sanitary requirements in product processing, and the diversity of processing stages through which the product passes. The special requirements for poultry processing also affect construction costs. For example, the high humidity prevailing in the processing areas of poultry plants makes wooden structures impractical. Consequently, concrete floors with masonry and structural steel superstructure are the most common building materials used in modern poultry-processing plant construction.

Finally, the development of the poultry-processing industry has been such that plants serving the industry have generally been confronted with the need for future expansion. Accordingly, the problem of providing for probable expansion needs should be considered when the costs for initial construction are estimated.

Prefabricated Buildings

Prefabricated building designs have improved in quality and variety so that a modern prefabricated building can be purchased to satisfy practically any

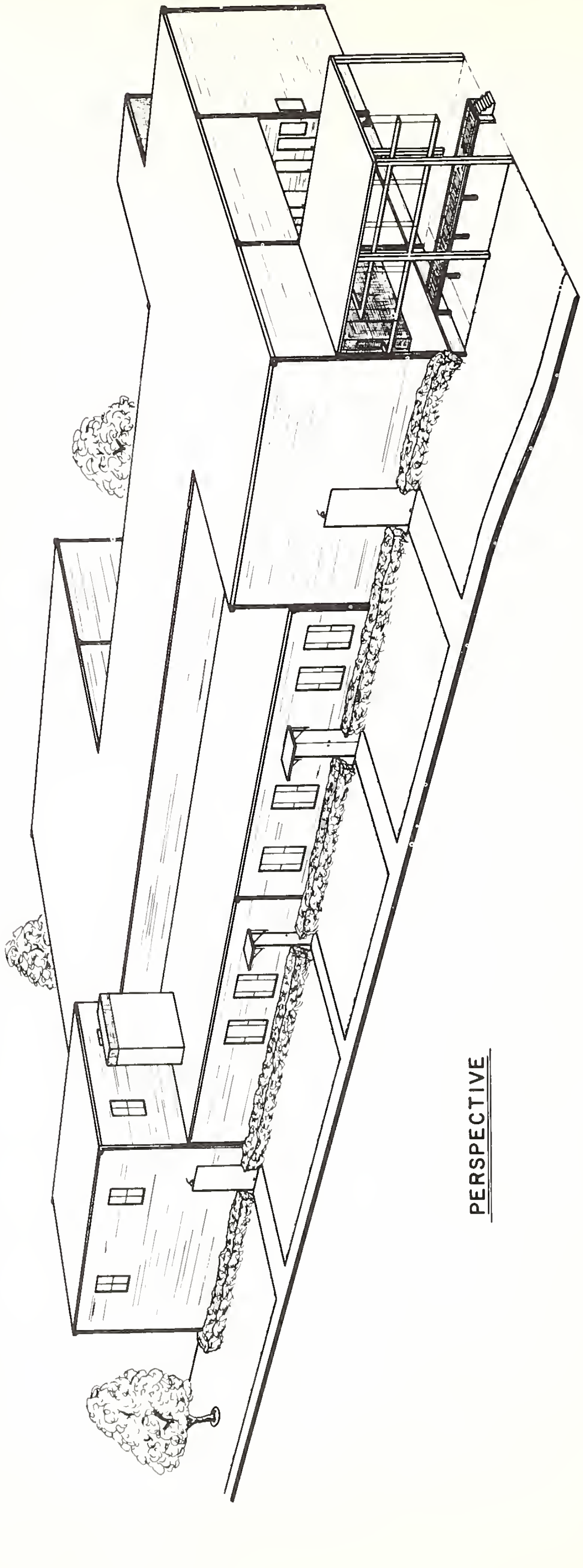

FIGURE 45.–Perspective drawing of a model poultry-processing plant.

need. At one time, prefabricated buildings were used primarily for sheltered areas, grain storage bins, warehouses, and other service facilities. However, designs are available now for all types of manufacturing plants.

Prefabricated structures have many features that are desirable for poultry-plant construction and are worth considering when a new plant is to be built. The principal desirable features of these structures are:

(1) They are preengineered and designed for strength, durability, and utility.

(2) Because of factory prefabrication of building sections, the building can be assembled on the site faster than a conventional structure.

(3) Inasmuch as the building load is carried on the frame structure, heavy concrete footings are needed only under steel columns. In addition, all walls may be nonload-bearing.

(4) Nonload-bearing walls can be removed for building expansion and the wall material can be used again for the new walls. This is of particular value to poultry processors because most poultry-processing plants are confronted with the problem of plant expansion to keep pace with the rapidly changing industry.

(5) Long clear spans, that eliminate column interference in positioning large pieces of equipment efficiently, are available.

(6) Wall sections can be obtained with both interior and exterior finishes of various colors of baked enamel paint. Roof and wall sections can be obtained fully insulated, with an inside finish impervious to moisture.

(7) The building can be disassembled and sold, or moved to a different location, if the need arises.

Concrete Masonry Building

Concrete masonry, particularly concrete block, is used quite frequently in poultry-plant construction. Various degrees of finish, from the unpainted block to the block with glazed surface, are available. This type of construction material has several advantages:

(1) Walls of concrete block (usually 8 x 8 x 16 inches) are very strong and durable;

(2) The walls are fire resistant and absorb noise readily if they are not glazed; and

(3) A glazed surface impervious to moisture can be applied where needed, to meet cleaning requirements.

Property Plat

Figure 46 presents an example of how a poultry-processing plant and surrounding area can be arranged on a rectangular site facing a roadway. Two access drives are provided for trucks and other vehicles entering or leaving the plant. The basic plant, expanded areas, and areas available for future expansion are designated. The parking areas immediately in front of the plant are convenient to the office and employee entrances for workers and visitors. Additional parking space for personnel required after plant expansion are provided to the right of the plant.

Adequate truck-maneuvering areas are provided adjacent to the receiving and shipping docks, the scale, the holding sheds, and the offal room. Truck access ways for delivery or removal of equipment are provided to the overhead doors in the shop, boiler room, defeathering area, refrigeration-machinery room, dry-storage room, and eviscerating area.

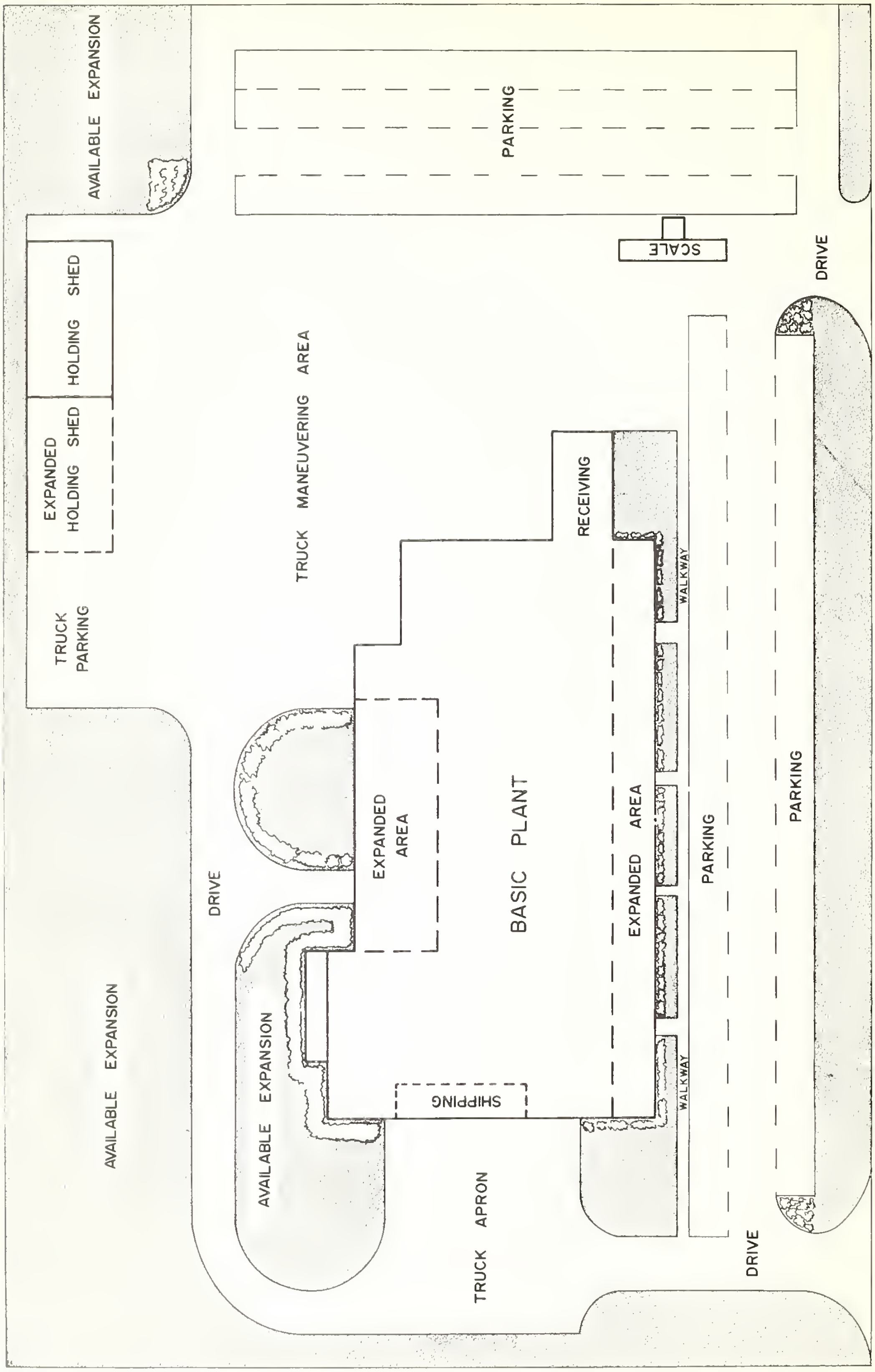

FIGURE 46.—Property plat for model poultry-processing plant shows building and area arrangement.

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